

New Scientist

WEEKLY 1 October 2022

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High flying Could drones help us build tall, intricate structures?

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Costa Rica: The science of biodiversity

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Video

Building on the fly

Check out drones working together to create 3D-printed cylinder structures made of foam or cement. The experiments are paving the way for a future where swarms of drones could help construct extremely tall or intricate structures.

youtube.com/newscientist

Newsletter

Wild Wild Life

News and digital director Penny Sarchet asks what exactly is a species? Why is it so hard to define? And is that a problem or even a good thing? She also brings news from the deep biosphere, which is the largest habitat you've never heard of.

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Essential guide

The Solar System

How does the sun work? Why does the moon matter? Is there alien life? Knowledge of our solar system has reached new heights – but there is still much to discover about our nearest planets and the worlds beyond. Explore more in the latest *New Scientist Essential Guide*.

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A note from the editor



Dear readers,

At *New Scientist*, we believe that science is the best tool we have for understanding our universe (or, possibly, universes) and all the extraordinary wonders that it (or they) may contain. We also believe that science and technology provide us with the best tools we have for tackling the very real challenges our world now faces.

All of this and more will be explored at our big live show at the ExCeL London, starting next week. This year, we have got four main stages: Mind and Body, Our Planet, The Future and The Universe, each offering fascinating talks from some of the world's top scientists and technologists.

On the exhibition floor, there will be numerous activities to try your hand at, exhibits to pore over and chances to meet the scientists, conservationists, academics and artists at our exhibition stands, all drawn together by their shared love of science and our precious natural world.

The show isn't called *New Scientist Live* for nothing, and this year, you will have the opportunity to properly meet many of our journalists, either at informal, fireside-style chats at our exhibition stand or at daily ask-us-anything sessions. Rowan Hooper and his team will also be recording a special "ask us anything" episode of the *New Scientist Weekly* podcast from the show: it's your chance to put us on the spot and to hear yourself on our podcast. If you have any questions you would like to send us in advance of the show, please do email them to editor@newscientist.com.

This year, Friday is for schools only, and then Saturday and Sunday are for everyone else. As I write, there are national rail strikes planned for the Saturday, but we very much hope our UK readers will find their way to us nonetheless. As we went to press, the news was that most Transport for London services, including the tube and buses, would be running. The exhibition centre also has parking. For more details on how you can get to the show, please go to newscientistlive.com.

All the very best to you, and for those who live close enough and are able, we hope to meet you at the show. For anyone too far away to come but who might still be interested, the show is available digitally this year. You can join the stream live or watch on-demand after the show.

Emily Wilson

New Scientist editor-in-chief



Physicist Carlo Rovelli speaking at New Scientist Live in 2018

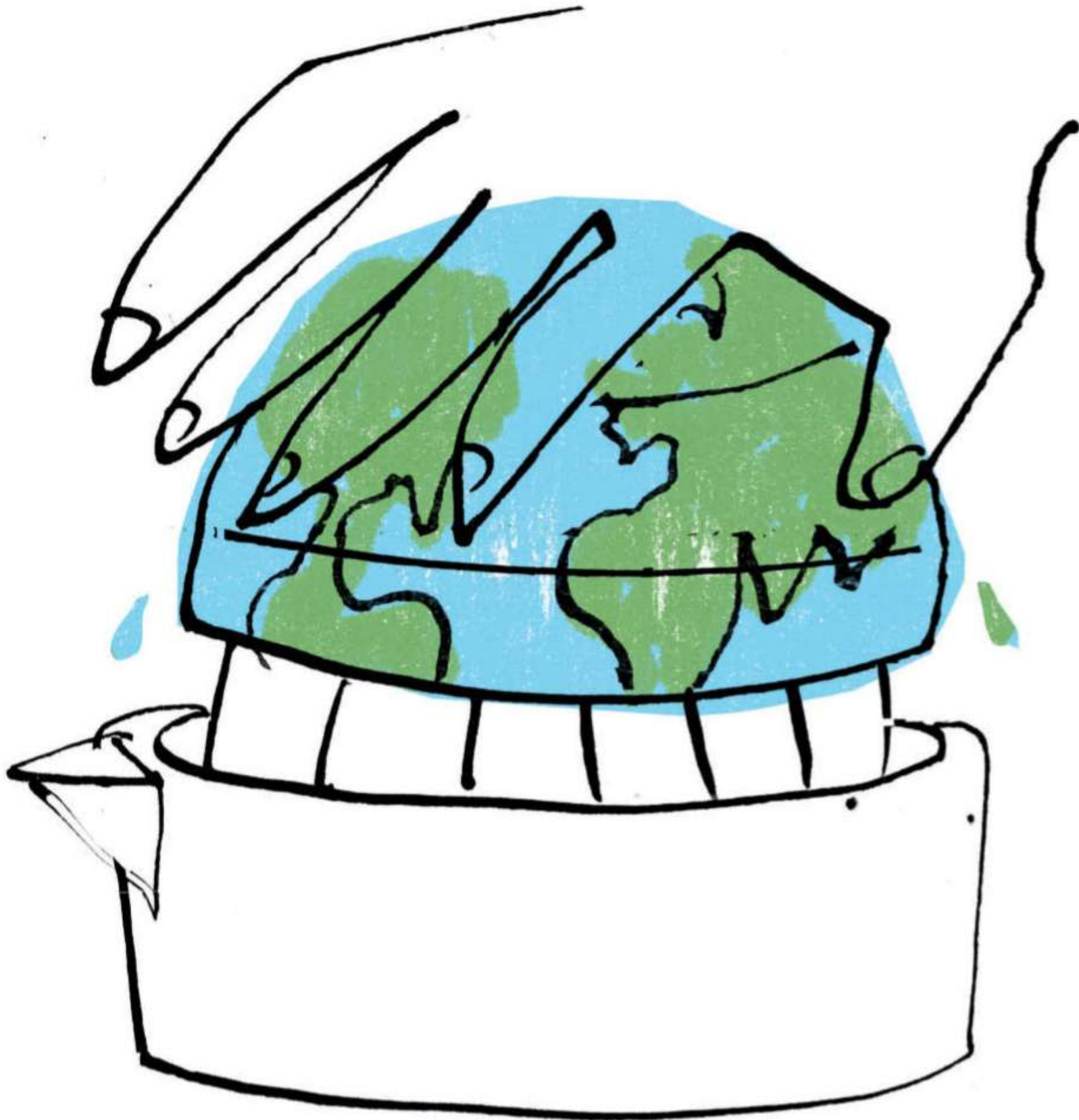


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No one size fits all

Progress on insomnia suggests we need a more nuanced approach to mental health

THERE can be few things more debilitating than going to bed, after a long and tiring day, and being unable to drift off. The harder you try to fall asleep, the more difficult it becomes – a vicious cycle of unwanted wakefulness that takes a significant toll on the lives of millions.

But it doesn't have to be this way, because a new, more nuanced understanding of insomnia has made it a solvable problem, as we report in our cover story on page 38. Underlying this improved understanding is the recognition that there isn't one type of insomnia but many – a departure from the standard "one-size-fits-all" approach to the diagnosis and treatment of mental health problems, which is failing.

This recent progress on insomnia, built

on identifying the different types and treating them accordingly, should be a flag-bearer for a new way to think about mental health problems more broadly.

Take depression. For decades, the go-to treatment strategy has been to prescribe drugs that boost levels of serotonin in the

"Underlying recent successes is the recognition that there isn't one type of insomnia but many"

brain and yet, as a recent study found, low levels of this chemical messenger don't appear to be the primary cause of the condition for most people. One person's depression isn't the same as another's. Instead, we should identify the different types of depression, and the different

causes, before considering treatments.

This approach – sometimes called precision psychiatry – isn't entirely new, and it is fair to say that progress has been slower than many would have hoped. Studies performed to-date indicate there may be limited scope for personalised treatments for mental health. And in the UK at least, there is a shortage of specialist mental health practitioners.

But that isn't to say we should give up on the idea. In other areas of medicine, such as cancer, personalised treatments are beginning to be made available, and some of those taking them have seen spectacular improvements in their health. With mental health problems continuing to rise across the world, even limited success would be transformative. ■

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© 2022 New Scientist Ltd, England. New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd



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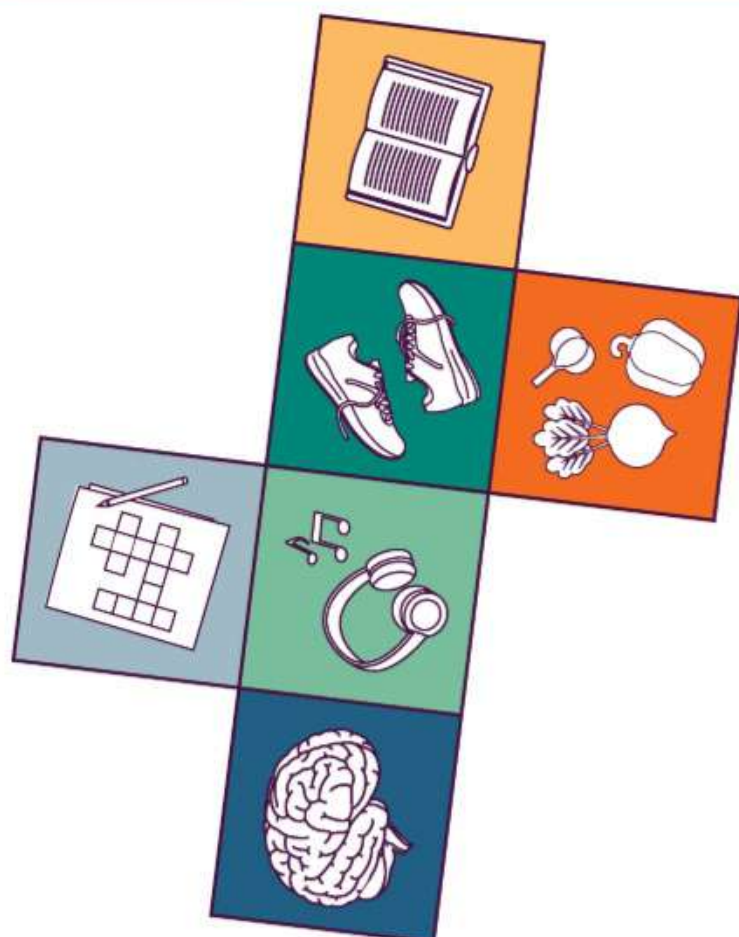
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Bubble trouble

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Under pressure

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Asteroid detectives

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Gut feeling

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Save the banana

Creating resistance to fruit-threatening fungus **p22**



KEN JACK/GETTY IMAGES

Environment

Alarm at UK growth push

Environmentalists are raising concerns over government plans for development that they fear will hit nature, reports **Michael Le Page**

WORRIES are rising that wildlife could be in the firing line of the new UK Conservative government bid to boost economic growth.

The administration's "mini-budget", unveiled by chancellor Kwasi Kwarteng on 23 September, included plans to set up low-tax investment zones with relaxed planning restrictions in parts of England. Separately, it has also emerged that it is likely to ditch plans under which farmers and landowners in England would be paid for helping preserve and enhance areas for wildlife.

This has led to a widespread outcry from environmentalists.

"This government has today launched an attack on nature," the UK's Royal Society for the

Protection of Birds stated on 23 September. "If they carry out their plans, nowhere will be safe."

"Rather than ramp up action to support our environment, this government appears, however, to be heading in the opposite direction," stated Hilary McGrady, the head of the National Trust, a charity that manages large areas of land in the UK.

"Everything we have and everything we do depends upon the health and vibrancy of... nature," tweeted Conservative MP Ben Goldsmith, implying a rethink is needed. "Britain is one of the most nature-depleted countries on Earth," he added.

Plans for the investment zones are vague, with no details yet

finalised. A fact sheet says: "The need for planning applications will be minimised and where planning applications remain necessary, they will be radically streamlined... We will set out further detail on the liberalised planning offer for Investment Zones in due course."

"This government has launched an attack on nature. Nowhere will be safe"

The government says it is in discussions with 38 local authorities in England to establish investment zones. The authorities cover most of England, but which areas will become zones appears

Planning rules in wildlife zones could be relaxed

to be up for negotiation. The government hopes to extend the scheme to Scotland, Wales and Northern Ireland.

There have been similar ideas in the UK and elsewhere before. The last government announced plans for "Freeports" where different regulations apply. What's more, there are already 48 "enterprise zones" across England that "benefit from tax and planning concessions", but have generated far fewer jobs than forecast, according to a 22 August House of Commons research briefing.

Sources within the government have also confirmed that the Environmental Land Management Scheme (ELMS) will be scrapped before it even comes into effect, according to *The Observer* newspaper. The idea was to pay farmers to manage land in a way that is more beneficial to wildlife and the wider environment.

Instead, farmers may get paid per area of land they own, as under the Common Agricultural Policy (CAP) of the European Union that the UK was meant to be moving away from after Brexit. Wildlife campaigners say the CAP has harmed biodiversity as a result of subsidising intensive agriculture and paying farmers to keep land clear even if it isn't used to grow crops.

The replacement of CAP with ELMS was seen by environmental campaigners as one of the few potential upsides to Brexit.

"The utter madness of this," said Craig Bennett at The Wildlife Trusts on Twitter. "If we revert to an agricultural system where people get given taxpayers' money on [the] basis of how much land they own, then one of the few potential environmental benefits of Brexit will have been squandered. It will be unfair and unsustainable." ■

Decision time for the Amazon If Brazil re-elects Jair Bolsonaro as president, the impact on the rainforest could be catastrophic, while his rival Luiz Inácio Lula da Silva is promising to reverse environmental damage, reports **Luke Taylor**

SINCE Brazilian president Jair Bolsonaro took office in 2019, deforestation records in the Amazon rainforest have repeatedly been broken as his administration pursued a policy of environmental deregulation. Now, ahead of the nation's 2 October election, the Amazon is under increased threat as land-grabbers are exploiting what could be their final opportunity to clear trees without retribution, says Philip Fearnside at the National Institute for Research in Amazonia.

The number of fires in the Brazilian Amazon usually increases in June, when ranchers take advantage of a drop in rainfall to clear land. But even for the dry season, the level of blazes in the Amazon this year has shocked conservationists: 31,513 fires were detected by Brazil's national space agency in August, the highest number in 12 years.

"People realise they can get away with ignoring all the current environmental regulations under Bolsonaro, but the end of his first term is looming and many assume he may not be re-elected," says Fearnside.

Issues like inflation and hunger are high on the political agenda, but the vote is also a referendum on the future of the Amazon, say researchers. "I don't say this lightly as a scientist, but this is the most important election ever in Brazil for the Amazon and its survival," says Erika Berenguer at the University of Oxford.

The amount of forest lost in the Amazon each year is now 75 per cent higher than when Bolsonaro took office, with 13,000 hectares cleared in 2021 alone, the largest annual figure since 2008. This deforestation has pushed the Amazon to a tipping point that could see the rainforest become a savannah.

ERALDO PERES/AP/SHUTTERSTOCK



Experts blame Bolsonaro for the destruction. The president has stripped environmental regulations, appointed military officials who seek to develop the Amazon to run environmental institutions and publicly encouraged colonisation of the rainforest. "The Bolsonaro administration has been a complete disaster for the environment," says Fearnside.

Bolsonaro's main opponent, Luiz Inácio Lula da Silva, was president from 2003 to 2010 and leads the latest polls with 41 per cent to Bolsonaro's 37 per cent. To win in the first round and avoid a run-off poll, scheduled for

75%
Increase in annual deforestation since Jair Bolsonaro took office

30 October, a candidate must gain 50 per cent of the votes. Former governor of the state of Ceará, Ciro Gomes, and senator Simone Tebet are also in the presidential race, but are outsiders, polling 8 and 6 per cent, respectively.

Lula says he will reverse the environmental damage

Jair Bolsonaro is facing off against Luiz Inácio Lula da Silva

by dissolving many of Bolsonaro's decrees, appointing experts to environmental agencies and purging Indigenous reserves of illegal miners.

The former president has also proposed more ambitious measures, such as the creation of a carbon-pricing scheme, a ministry dedicated to Indigenous peoples and a National Climate Change Authority to ensure Brazil's policies are in line with its Paris Agreement targets.

Conservationists have raised concerns over mega-dams constructed when Lula was in power, but the former union leader has a strong track record on defending the Amazon: deforestation plunged 72 per cent between 2004 and 2016, when Lula and then his successor Dilma Rousseff – also representing the Workers' party – were in power.

Lula's administration made Amazon conservation a central goal for all government ministries, says Suely Araújo at the Climate Observatory in São Paulo. As well

as stepping up forest monitoring, they sought to tackle the causes of deforestation by promoting sustainable production and formalising land ownership.

The task this time would be more complicated. Growing mining communities depend on the illicit gold they extract from Indigenous reserves, new roads have been constructed and regions of the Amazon have become lawless.

If elected, Lula's strategy will have to be more ambitious this time round, says Izabella Teixeira, his adviser on the environment and Brazil's environment minister from 2010 to 2016. As well as military operations to clear the Amazon of illegal miners, loggers and ranchers, the government has to improve regulation of food and gold markets, incentivise sustainable production and use technology to make agriculture more sustainable, she says.

"I think that Lula is very cautious to understand that this is a huge challenge and is completely different than it was in the past," says Teixeira.

Lula would unite the government with the private sector, scientists and civil society to tackle the root causes of deforestation, Teixeira adds. As president, he would also seek to restore the international relationships and conservation funding that have been lost under Bolsonaro, turning Brazil into a global leader on tackling climate change, she says.

Meanwhile, Bolsonaro has played down the growing deforestation. He told the UN General Assembly in New York on 20 September that the Amazon is as pristine today as it was in the 1500s. His office didn't respond to a request for comment. ■

Health

Gene therapy infused into the brain eases debilitating rare condition

Alice Klein

A GENE-REPLACEMENT therapy that is administered directly to the brain has allowed some children with a rare genetic condition to walk and talk for the first time.

"It's a dream come true," says Richard Poulin, whose daughter Rylae-Ann received the therapy in November 2019, aged 18 months. Rylae-Ann, who lives in Thailand, went from being unable to say any words, move or even lift her head to "running, jumping, kicking a ball, riding a horse, swimming and speaking in multiple languages", according to Poulin.

Rylae-Ann was born with AADC deficiency, a genetic condition with fewer than 150 documented cases worldwide. It is caused by a faulty variant of a gene called *DDC* that prevents the brain from making dopamine and serotonin.

Without these important neurotransmitters, children with AADC deficiency "don't have head control, they cannot sit up, they cannot walk or talk – they are bedridden", says Wuh-Liang Hwu at the National Taiwan University Hospital, who led a clinical trial of the gene therapy, called Upstaza.

Many also experience "oculogyric crises", where their eyes roll up into their heads. Most die at a young age, he says.

Upstaza was developed by PTC Therapeutics, a pharmaceutical company based in New Jersey. It replaces the faulty *DDC* gene with a version that functions normally. This version is delivered into brain cells via a virus called

Rylae-Ann was unable to move before the gene therapy



JUDY WEI

adeno-associated virus type 2, modified so it doesn't harm. The treatment is infused into a part of the brain called the putamen through a small hole that is drilled into the skull.

Since 2010, Hwu and his colleagues have trialled the gene therapy in 30 children with AADC deficiency at the National Taiwan University Hospital. The children ranged from 18 months to 10 years old at the time of treatment, and mostly lived in Taiwan and other South-East Asian countries, where the condition is most prevalent.

Following treatment, the children all improved in their motor and cognitive function, and had fewer oculogyric crises, according to clinical trial results presented at the annual symposium of the Society for the Study of Inborn Errors of Metabolism in Freiburg, Germany.

"The ones who got it before 4 years of age, it's quite a dramatic difference," says Hwu. "We say they have been reborn."

Rylae-Ann sat up just one month after receiving the gene therapy. She is one of seven trial

participants who have since learned to walk and one of three who have learned to talk. "Speech is the most difficult thing for patients to learn because it uses so many muscles," says Hwu.

A common side effect of the gene therapy was dyskinesia, or sudden uncontrolled movements, but this resolved in all cases.

In the past, some early gene therapies caused cancer. Upstaza shouldn't stimulate abnormal cell growth because the virus used to deliver the *DDC* gene variant is non-replicating, as are the brain cells it is delivered to, says Hwu.

The gene therapy was approved by the European Medicines Agency in July. PTC Therapeutics plans to seek approval from the US Food and Drug Administration.

Poulin says the therapy has worked better for Rylae-Ann, now 4, than he and her mother Judy could have ever hoped. "We didn't know what to expect – would she be able to lift her head? But now, when I get home, she runs up and gives me a big hug and kiss and says, 'Daddy, Daddy, I love you,'" he says. "It's incredible." ■

Astronomy

Hot electron bubble whizzes around our galaxy's black hole

A BUBBLE of hot electrons appears to be circling Sagittarius A*, the supermassive black hole at the centre of the Milky Way, at extraordinary speeds. This strange bubble could help us learn about how black holes devour the material around them.

Maciek Wielgus at the Max Planck Institute for Radio Astronomy in Germany and his colleagues used the Atacama Large Millimeter/

submillimeter Array (ALMA) in Chile to observe the area surrounding Sagittarius A* as the black hole was emitting a huge flare of X-rays.

Minutes after the flare occurred, the researchers saw an enormous "hot spot" of radiation, most likely made up of electrons heated to billions of degrees, circling the black hole on an orbit roughly the distance that Mercury's sits from the sun in our solar system.

Mercury takes 88 days to orbit the sun, whereas it only took this bubble about 70 minutes to make a loop around Sagittarius A*, meaning that it was travelling

at about 30 per cent the speed of light. The researchers were only able to see it for two orbits before it faded from view, meaning it was either destroyed or was no longer emitting light in wavelengths ALMA can observe (*Astronomy & Astrophysics*, doi.org/gqvmcw).

"The bubble cannot be too small, because a small bubble would not disappear that quickly," says Wielgus. A small bubble would

"The bubble cannot be too small, because a small bubble would not disappear that quickly"

experience less shear force as it travelled around the black hole, so it would live longer. "It's a huge bubble, it's not a tiny little guy."

From observations of the two orbits, the researchers managed to determine that the magnetic fields affecting the bubble seem to be aligned as we would expect them to be based on a model of black holes called the magnetically arrested disc model.

"It tells us that maybe our models of these systems really have something to do with reality," says Wielgus. ■ Leah Crane

Climate change

Decarbonising shipping will cost more than \$1 trillion

James Dinneen

MORE than \$1 trillion of investment is required to decarbonise the shipping industry by 2050, according to a report released at the Global Maritime Forum summit in New York during Climate Week NYC.

The shipping industry is responsible for about 3 per cent of total global greenhouse gas emissions. Most of the industry's emissions come from fossil fuels burned to propel the more than 100,000 large ships on the ocean – and total emissions could more than double by 2050 without efforts to decarbonise.

Improving energy efficiency could significantly reduce emissions from shipping, but fully decarbonising requires replacing fossil fuels outright with zero-emissions fuels produced using renewable energy and methanol, says Domagoj Baresic at University Maritime Advisory Services, a shipping consultancy in the UK.

Baresic and Katharine Palmer at Lloyd's Register, a maritime services company in the UK, considered what progress the

shipping industry has made so far, focusing on what they call a “breakthrough” target of using zero-emission fuel for 5 per cent of international and 15 per cent of domestic shipping fuels by 2030.

“Even though 5 per cent sounds small, it implies that all of the necessary conditions start being in place” for rapidly increasing use of zero-emission

3%

The shipping industry's contribution to global emissions

fuel from that point on, says Baresic. Almost no zero-emission fuel is currently used for shipping, he says.

The International Maritime Organization, the UN agency that regulates international shipping, has adopted a strategy to reduce shipping emissions by 50 per cent by 2050. A more ambitious plan to reduce shipping emissions by 100 per cent by 2050 has been signed by at least 14 countries, including the US and the UK.

“Two years back, there was

literally nothing happening in the shipping space [on decarbonisation],” says Rasmus Bach Nielsen at Trafigura, a global commodities trading company.

Despite commitments, the industry is only “partially on track” towards the 2030 targets, the report finds.

“Now we're at that stage where it's about seeing commitments turn into real-world actions,” says Baresic. “Is the money there? Are we actually seeing the construction of the ships and the infrastructure?”

The report counts at least 203 green shipping pilot projects underway but says those must now translate to longer-term commitments, such as investments in zero-emission fuel infrastructure. Some ships could be powered with electric batteries, nuclear power or even wind-powered sails, though the report considers zero-emission fuels to be the central strategy.

Twenty-two countries have also committed to create six zero-emissions shipping routes by 2025, which could help create the infrastructure needed to scale up green shipping.

In all, the report estimates that decarbonising global shipping by 2050 would require between \$1 trillion and \$1.4 trillion of investment.

“It's a big number,” says Baresic, but it would derive from global investments from many industries spread over decades.

“Now we've got a common destination,” says Palmer. “The question is how fast will we go there.” ■

A tanker near the commercial port of Piraeus, Greece



SHUTTERSTOCK/AERIAL-MOTION

Animals

Blood vessel web protects the brain of a swimming whale

Corryn Wetzel

A NETWORK of blood vessels in whales' brains may protect them from powerful pressure pulses generated during swimming.

Whales get around by moving their tails up and down which, in combination with breath-holding, sends a wave of pressure from the tail to the head. This would typically cause injury to the brain, but whales manage to evade such damage.

“The squeezing actions create pressure pulses which can travel in the blood through veins or arteries,” says Robert Shadwick at the University of British Columbia in Canada. “Unlike a running mammal, [whales] cannot alleviate the locomotion-induced pulses by exhaling air.”

Researchers discovered blood vessel webs known as retia mirabilia in the brains of deep-diving whales in the 1600s. To investigate their function, Shadwick's team created a model that simulates pressure changes in a whale while swimming, based on the characteristics of 11 cetaceans.

The analysis revealed that retia mirabilia help maintain steady blood pressure in the brain without dampening the pressure pulses or the power of the whale's tail (Science, doi.org/gqvnkm).

The web of blood vessels reroutes pressure from arteries entering the brain to veins leaving it, protecting the organ from pressure swings without changing how blood moves elsewhere.

“The simulations showed that the retia [mirabilia] could eliminate over 90 per cent of the harmful effect of locomotion-induced pulses by this transfer mechanism,” says Shadwick.

The work also helps explain why marine mammals like seals lack retia mirabilia. They swim via side-to-side undulations, so avoid sending a hazardous pressure pulse to the brain. ■

Astronomy

Neptune on display

A stunning view of the planet's rarely seen ring system from JWST

Leah Crane

THE James Webb Space Telescope (JWST) has seen Neptune's rings and some of its moons.

Neptune appears blue in visible wavelengths due to methane gas in its atmosphere, but the gas absorbs the infrared light that JWST observes, so the planet appears to glow a white colour here. The brightest areas are icy clouds high in the atmosphere, which reflect sunlight before methane can absorb it.

Also visible are Neptune's two bright rings, and two fainter ones. The rings are full of dust, which makes them dimmer and harder to spot than shining, icy rings like the ones that encircle Saturn.

"It has been three decades since we last saw these faint, dusty rings, and this is the first time we've seen them in the infrared," said JWST scientist Heidi Hammel in a statement, referring to when NASA's Voyager 2 spacecraft flew past the planet in 1989. ■



NASA, ESA, CSA, STScI

Technology

Robot navigates rooms using magnetic fields

A ROBOT can autonomously navigate inside a building using a magnetometer and a detailed map of local magnetic anomalies.

The technique could provide a means for people as well as robots to find their way around large buildings.

Satellite navigation systems like Russia's GLONASS and the European Union's Galileo can provide accurate location information all over the planet, but they have weaknesses. Signals can be jammed in times of conflict, as GPS signals currently are in Ukraine, and they tend to be difficult to pick up indoors.

The US Air Force has run tests of magnetic anomaly navigation

on fighter jets, which relies on the unique patterns produced by the geology of Earth's crust and, crucially, can't be jammed.

Now, Prashant Ganesh at the University of Florida and his colleagues have collaborated with a scientist from the Air Force Research Lab at Eglin Air Force Base in Florida to demonstrate that a similar technique can be used indoors by robots.

The team created a map of the magnetic anomalies in an 11-metre-by-6-metre area of a lab and showed that a robot equipped with a magnetometer could navigate to waypoints despite not being told its starting position.

Ganesh says Air Force tests

have focused on taking magnetic measurements and GPS readings together to test the accuracy of the concept, and his team's robot is one of the first demonstrations of real-time, autonomous magnetic anomaly navigation.

The team's small robot takes a reading of the magnetic field at its initial location and generates a database of possible locations based on its anomaly map. As the robot moves – at a constant rate of 20 centimetres a second – it gathers more readings, and ranks

"Metal pipes beneath the floor became landmarks for the robot just as mountains are for aircraft"

its location guesses in terms of probable correctness. Within several readings, the robot can determine where it is and begin to navigate to a target destination (arxiv.org/abs/2208.00988).

Ganesh says that when mapping the lab, the sensors picked up on metal pipes beneath the floor, which became landmarks for the robot just as mountains or ridges would be for an aircraft.

It may be some time before magnetic navigation becomes a practical consumer tool. The magnetic sensors used cost \$10,000 and, at 16 centimetres long, are too bulky to fit inside a smartphone or tablet. ■

Matthew Sparkes

Health

Genes may raise chronic fatigue risk

Almost 200 genetic variants were identified in 91 per cent of people with the condition

David Cox

SCIENTISTS have discovered possible genetic risk factors involved in chronic fatigue syndrome (CFS), also known as myalgic encephalomyelitis (ME).

ME/CFS is a poorly understood condition that affects around 17 million people worldwide.

To better understand its cause, Steve Gardner at UK biotech firm PrecisionLife and his colleagues analysed DNA samples from 2382 participants of the UK Biobank study, who all had ME/CFS.

Most genetic studies look for differences in individual DNA letters, known as single nucleotide polymorphisms (SNPs). Gardner and his colleagues instead hunted for differences in combinations of SNPs, allowing them to identify genetic traits that may only be in a subgroup of people with ME/CFS.

The team identified 199 SNPs, of 14 genes, in 91 per cent of the participants with ME/CFS (medRxiv, doi.org/jdgb).

A statistical analysis suggests this wasn't a chance finding.

Previous studies have linked these genetic variants to our overall stress response, our circadian rhythm or body clock and the mitochondria that power our cells. People with these

"These findings could significantly accelerate new diagnostics and novel drug discovery"

variants may also be at heightened risk of catching viral and bacterial infections or developing certain autoimmune conditions.

Research suggests that around 70 per cent of people with ME/CFS report that their symptoms began after an infection. Many with the condition also commonly experience sleep disturbances and symptoms associated with autoimmune conditions, such as muscle and joint pain.

According to Gardner, identifying the genetic variants provides clues as to the underlying mechanisms of ME/CFS.

"These findings allow us to now target research towards these areas, which could significantly accelerate both the discovery of new diagnostics and provide a feasible background for novel drug discovery," he says.

There are no diagnostic tests for ME/CFS, with people often told symptoms are psychosomatic.

Identifying these variants is insufficient to make a diagnostic test, as they indicate whether someone is at a heightened risk of ME/CFS, not that they have the condition, says Gardner. But they could point in the right direction.

"Knowing the genes allows us to see which processes are involved in the disease," says Gardner.

"We may be able to spot some of the products of those metabolic processes in the blood, which

could help lead to a blood test or some other relatively non-invasive test."

Chris Ponting at the University of Edinburgh, UK, says the findings could lead to new treatments, but warns that the study was relatively small for genetic research and the results need to be replicated.

Ponting is involved in the DecodeME study, which is analysing DNA samples from 25,000 people with ME/CFS. If the same 14 genes are identified, it could lead to work into blocking those pathways in tissues to help alleviate the symptoms of ME/CFS.

"If DecodeME were to find the same thing, it would really be quite exciting," says Ponting. "Knowing whether CFS is a disease of, say, mitochondria or the nervous system or an immune system disease, will be a huge step forward. At the moment, there's a rather scattergun approach to looking at all things." ■

Chemistry

The recipe for perfect bubbles, according to science

RESEARCHERS have worked out the optimal recipe for making giant, long-lasting soap bubbles. It should allow anyone to reliably blow bubbles at least 12 centimetres across and potentially create some large enough to envelop a person.

Marina Pasquet, who carried out the work with her colleagues at the University of Paris-Saclay, started the project by investigating liquids that artists and performers were using to make giant bubbles. "There are a lot of recipes out there," says Pasquet, who is now at the University of California, Berkeley.

Soap bubbles are essentially

packages of air surrounded by an iridescent liquid film. A phenomenon known as the Marangoni effect, which influences the flow of molecules on the surface of bubbles, helps to keep their surface intact.

The amount of detergent has to strike a balance: with more detergent, the bubbles become easier to blow, but their lifespan also drops, says Pasquet.

That is probably all that most people would add at home, but the researchers found that two extra ingredients can lift your bubbles to another level. Chemicals called long aqueous polymers increase a characteristic known as elongational viscosity, keeping the film of the bubble stable as you blow it, says Pasquet. Common



Marina Pasquet and her team experimented with large bubbles

glycerol, also known as glycerine, which helps the ingredients mix well so the solution consistently forms bubbles. The glycerol can also slow evaporation of the water in the bubble's film, which allows it to last for longer, says the team.

The ideal recipe, according to the researchers, is 85.9 per cent water, 4 per cent washing-up liquid, 0.1 per cent guar gum and 10 per cent glycerol. This mix enabled the team to reliably create big, long-lasting bubbles (arxiv.org/abs/2209.04435). One example about 12 centimetres across lasted 24 hours in the lab, says Pasquet. ■

Chris Simms

Technology

Radio wave attack makes cameras see phantom images

David Hambling

A CYBERATTACK that uses radio waves to fool image-recognition systems can stop them working. So far, it can disrupt a barcode scanner and alter frames captured by cameras, but it could potentially make digital detection systems see things that aren't there.

Digital cameras contain sensors that convert light into electrical pulses. Additional electrical signals induced in the circuit going from the sensor to other parts of the system, known as post-transducer signals, can give the false impression that the camera has seen something.

Sebastian Köhler at the University of Oxford and his colleagues have used radio waves to induce these signals and manipulate a barcode scanner from half a metre away.

The slight blurring effect on a photo the scanner takes of a barcode is barely visible to humans, but caused the scanner to fail to read barcodes 99 per cent of the time. This attack simply added "noise" to the data the camera was collecting, but Köhler says his team has introduced actual shapes into images in such attacks.

He presented the research at the 17th ACM ASIA Conference on Computer and Communications Security in Nagasaki, Japan.

The attack works on cameras that rely on technology called charge-coupled device image sensors, used in many scientific applications and military surveillance systems, but wouldn't work on the image sensors used in most consumer devices, such as smartphones.

In a military context, such attacks could create phantom images, for example to make an autonomous vehicle detect non-existent obstacles in its path to get it to change direction. Any attacker would need to be nearby, though. "An attack from tens of metres is possible with reasonably sized hardware," says Köhler. ■

Environment

Guatemala's decimated rainforest is on the mend

Luke Taylor



MARIANA DIAZ/WCS

A COMMUNITY-LED conservation programme in Guatemala has started to reverse two decades of devastating deforestation.

Life is now returning to swathes of the Maya Biosphere Reserve that were illegally cleared 13 years ago. Regeneration of the forest means it was 25 square kilometres larger in 2020 than in 2019 and grew another 3.5 km² in 2021. What were uniform pastures punctuated with bare trees in 2009 have become blankets of forest teeming with tropical birds and monkeys once more.

Trusting local communities and emboldening them with scientific research was key to the forest's survival, says Gabriela Ponce Santizo, director of the Wildlife Conservation Society (WCS) Guatemala programme, which supported the project.

Researchers helped to find sustainable ways for communities to live off the forest without cutting down too many trees – a model that could be emulated across the world.

"As long as the forest can provide the people with the livelihoods they need, they

will be the guardians of this forest," says Ponce Santizo.

The reserve stretches across 21,000 km², making up around a fifth of Guatemala's total land area and a large part of the Maya Forest – the second-largest tropical rainforest in the Americas after the Amazon – shared with Belize and Mexico.

25 km²

How much the Maya Biosphere Reserve grew by in 2020

Ancient Maya ruins are scattered through the reserve as well as myriad communities and endangered species such as jaguars and scarlet macaws.

In 2009, the reserve was thought to be all but lost, says Ponce Santizo. Ranchers were torching as much as 8 km² of forest a day to clear land to raise cattle for profit and use their businesses to launder money for drug traffickers.

Bold actions taken then seem to have put the reserve on the road to restoration. The government evicted ranchers and prosecuted those with links to the drug trade before joining forces with the army, local

Ancient ruins are dotted throughout the Maya Forest

communities and rangers to protect and monitor the forest.

Community leaders were threatened by those being evicted and one was killed, says Ponce Santizo. "There were a lot of brave people, both in the authorities and local communities," she says.

The key to the turnaround was putting communities at the heart of the strategy, says Ponce Santizo. Local communities were granted control of the forest by the government, provided they conserve it, while researchers at Guatemala's National Council for Protected Areas helped them divide it for different crops.

The communities now live sustainably by harvesting products such as allspice, gum and pepper. The areas that are used for this rotate after a period determined by the sustainability of the resource and the time it takes forest to regenerate.

Some trees are cut down for timber, but 10 per cent of those in harvested areas are left to seed regrowth. The parts of the forest designated for this alternate every five years, so that by the end of a 25-year cycle, the first part of the forest used has fully regenerated.

The gains in the past two years are a fraction of the 270 km² lost since 2000, says the WCS, but the reserve has switched from annual net loss to net gain.

"The lessons of the Maya Biosphere Reserve can be transferred elsewhere in all tropical forests," says Carlos Nobre at the University of São Paulo in Brazil. ■

Astrobiology

Moss from Earth could grow under the light of another star

Alex Wilkins

ALGAE, moss and bacteria can all survive and grow in the light produced by a red dwarf star, according to experiments on Earth. This boosts the idea that planets around red dwarf stars like TRAPPIST-1 could host life.

The most promising exoplanets for life orbit stars that are smaller and cooler than our sun, so they radiate different profiles of light.

For instance, a star like TRAPPIST-1 would give out more infrared light. But we know little about how this would affect life.

Last year, Nicoletta La Rocca at the University of Padua in Italy and her colleagues tested how organisms from Earth might fare under simulated starlight by placing several types of cyanobacteria (also known as blue-green algae) in a starlight generator consisting of 273 controllable LEDs, which could mimic sunlight or red dwarf light.

The cyanobacteria, which are efficient at photosynthesising – getting their energy from sunlight – and can work in low and redder light, grew almost as well under the

273

The number of LEDs used to copy the light from a red dwarf

artificial red dwarf light as they did under the simulated light from the sun.

This is important, La Rocca told the Europlanet Science Congress in Granada, Spain, on 19 September, because cyanobacteria were crucial in making Earth habitable for other organisms. “They totally changed our planet, being responsible for the start of



L. ROCCA ET AL.

oxygen production,” she said.

La Rocca told the conference that her team has now put other types of organisms in the simulator that aren’t as good at harvesting light as the cyanobacteria, such as the microalgae *Chlorella vulgaris* and *Chromera velia*, and a moss, *Physcomitrella patens*, to test how they might fare.

Although all the organisms were able to grow under the artificial red dwarf light, most of them grew slightly less than they did under the simulated sunlight – except for one species, *C. velia*, which grew more.

La Rocca and her team also noticed that under artificial starlight, the moss failed to grow certain reproductive structures that are normally present under sunlight. “Maybe the organism can grow but no longer reproduce. This will deserve more investigation,” La Rocca told the conference.

The team also tested how much oxygen was produced by each species of cyanobacteria under different simulated lights and found that they would all contribute to an atmosphere

under red dwarf starlight.

Next, La Rocca’s team hopes to test how much oxygen the more complex organisms produce, and to make mathematical models to evaluate the possibility of these organisms existing on planet surfaces.

Complex organisms

Using organisms from Earth to evaluate how habitable alien star systems could be isn’t straightforward, says Michael Phillips at Johns Hopkins University Applied Physics Laboratory in Maryland.

“It’s very difficult to imagine life in other star systems evolving exactly how it evolved on Earth,” he says. “So while it’s interesting to see how a photosynthetic organism might respond to different starlight, those organisms are still very complex, and it took billions of years of evolution on Earth to get them.”

However, the work gives us a baseline for hypotheses to test when looking at the light spectra that come from worlds orbiting different stars, says Phillips. ■



The LED simulator that was used to mimic a red dwarf star’s light in experiments on Earth

Fertility

Sperm move in packs to push through vaginal fluid

Christa Lesté-Lasserre

SWIMMING in a pack may help sperm push upstream through thick vaginal and uterine mucus.

Sperm are often represented as individuals racing to fertilise an egg, but this is based on flat views of microscope slides and other settings that don’t reflect their natural context, says Chih-Kuan Tung at North Carolina Agricultural & Technical State University.

When placed in a mock-up of the female reproductive tract, bull sperm – which are similar to human sperm – appear to team up.

To better understand why, the researchers injected 100 million fresh bull sperm into a silicone tube containing fluid that resembled cows’ cervical and uterine mucus. Then, they used a syringe pump to create two speeds of flow.

When there was no flow, the clustered sperm swam in a straighter line than the individual sperm. In an intermediate flow, the clusters could swim upstream, unlike individual sperm. When the flow was strong, the clustered sperm pushed through far better than individual sperm, which usually got swept away (*Frontiers in Cell and Developmental Biology*, doi.org/jdck).

There was never one “leader” that was supported by others, says Tung. Instead, the arrangement resembles cyclists riding together in a peloton to encounter less air resistance. “It could be this kind of mechanism that just allows that at least some of them will eventually get to the oviducts,” he says.

The clusters probably serve a role in the thick outflowing mucus in the vagina and cervix as well as in the uterus, where contractions push fluids in multiple directions, he says. As sperm reach the oviducts, where fluids are thinner and less mobile, it is possible they swim individually.

The findings open new avenues for helping diagnose unexplained infertility, says Tung. ■

Fears of AI-driven global disaster

A third of scientists working in AI say it could cause catastrophe on the scale of nuclear war

Jeremy Hsu

MORE than one-third of artificial intelligence researchers around the world agree that AI decisions could cause a catastrophe as bad as all-out nuclear war in this century.

The findings are from a survey of 327 researchers who recently co-authored papers on AI research in natural language processing. In recent years, there have been big advances in this area, with the development of large language AI models capable of writing computer code or creating novel images from text prompts.

The survey, by Julian Michael at New York University and his colleagues, reveals that 36 per cent of all respondents think nuclear-level catastrophe is possible.

“If it was actually an all-out nuclear war that AI contributed to, there are plausible scenarios that could get you there,” says Paul Scharre at the Center for a

New American Security, a think tank based in Washington DC. “But it would also require people to do some dangerous things with military uses of AI technology.”

US military officials have expressed concern about arming drones with nuclear weapons, let alone giving AI a major role in nuclear command-and-control systems. But Russia is reportedly developing a drone torpedo with autonomous capabilities that could deliver a nuclear strike.

Fears about possible nuclear-level catastrophe were even greater when looking specifically at responses from women and people in underrepresented groups: 46 per cent of women saw this outcome as possible, as did 53 per cent of people in minority groups.

The survey may even have underestimated AI researchers’

concerns. Some respondents said they would have agreed that AI poses serious risks in a less extreme scenario than an all-out nuclear war (arxiv.org/abs/2208.12852).

“Concerns brought up in other parts of the survey feedback include the impacts of large-scale

“If it was an all-out nuclear war that AI contributed to, there are plausible scenarios”

automation, mass surveillance or AI-guided weapons,” says Michael. “But it’s hard to say if these were the dominant concerns when it came to the question about catastrophic risk.”

Separately, 57 per cent of all respondents saw developments in large AI models as “significant steps toward the development of artificial general intelligence”.

That evokes the idea of an AI with intellectual capabilities equalling those of humans. Seventy-three per cent also agreed that AI automation of labour could lead to revolutionary societal changes on a par with the industrial revolution.

Given that researchers expect major advances in AI capabilities, it is somewhat heartening that just 36 per cent see a catastrophic risk from AI as plausible, says Scharre. But he cautioned that it is important to pay attention to any risks related to AI that can impact large swathes of society.

“I’m much more concerned about AI risk that seems less catastrophic than all-out nuclear war but is probably likely, because of the challenges in dealing with the systems as we integrate them into different industries and military operations,” says Scharre. ■

Genetics

Mutation that helps bowhead whale live longer shrinks testes

BOWHEAD whales are the longest-lived mammals known, with one male estimated to have been 211 years old when it died. Now, it has been found that the whales have a gene duplication that appears to slow the division of cells, allowing them to live longer – but at the cost of reduced male fertility.

The long life of bowheads is likely to be a result of many genes, but this particular gene being duplicated is probably pretty significant, says Vincent Lynch at the University at Buffalo in New York, whose team made the discovery.

One of the greatest obstacles to a long life is that the longer you live, the more time there is to



TONY WU/NATUREPL.COM

acquire cancer-causing mutations.

Yet long-lived animals such as elephants and whales have very low rates of cancer, probably because they have evolved mechanisms for preventing tumours.

For example, even low levels of DNA damage trigger cell death in

elephants, killing cells before they can turn cancerous. But bowheads seem to have another strategy.

“The alternative is to keep the cell from dividing and give the cell time to fix the damage,” says Lynch.

This is what he thinks happens in bowhead whales as a result of the

Bowheads (*Balaena mysticetus*) are thought to be the longest-lived mammals

duplication of a gene called **CDKN2C** ([bioRxiv, doi.org/10.1101/2022.08.12.501133](https://doi.org/10.1101/2022.08.12.501133)).

Studies have shown that high levels of the protein this gene encodes halt cell division and prevent programmed cell death. It has a similar effect in bowhead whales, Lynch’s team has found.

Other studies have also shown that higher levels of this protein affect male fertility by influencing how many cells are involved in generating sperm, says Lynch.

The testes of bowheads are relatively small, weighing about 200 kilograms compared with 1000 kg for the closely related right whale, which doesn’t have the mutation, the team notes. ■

Michael Le Page

Astronomy

Fireball traced to space rock that made it

Will Gater

ASTRONOMERS searching for the origins of a small asteroid that exploded over the Pacific Ocean in September 2020 have found an archive picture of it, in space, taken minutes before the impact, in the first discovery of its kind.

David Clark at the University of Western Ontario in Canada and his colleagues analysed satellite data of previous fireballs, identifying ones created by space rocks big enough to show up in telescopic surveys, which routinely monitor the skies. After calculating the orbital path of each rock prior to it hitting Earth, Clark and his team scoured archive imagery of patches of sky where it might have been caught on camera.

They had one success. For a 0.4-kiloton fireball that exploded over the Pacific Ocean in September 2020, the researchers found what they believe is the trail of an unknown asteroid in archival data from the Asteroid Terrestrial-impact Last Alert System project. Crucially, studying this imagery allowed the researchers to glean more information about the space rock (arxiv.org/abs/2209.04583).

"We were able to better define the original orbit, acquired hints on shape, and were able to measure its magnitude, giving us constraints on how its size and surface brightness relate," says Clark.

The finding means that a total of six asteroids that hit Earth have now been observed in space, but this is the first to be uncovered in archival data after its impact had already occurred. The other five were all discovered and examined before entering the atmosphere.

Work like this can help astronomers learn more about near-Earth asteroids, including their composition and what risk they pose, says Clark, who intends to carry on the project by searching through updated satellite and sky-survey data. ■

Analysis Wildlife

Unsustainable conservation Cheetahs have been reintroduced to India for the first time in 70 years, but the project has drawn criticism, reports Lou Del Bello



DIRK HEINRICH/AP/SHUTTERSTOCK

A cheetah about to be transported from Namibia to India

What's more, these cats are an inherently fragile species – just 5 per cent of cheetahs make it to adulthood, says Karanth. Even in the 19th century, when India wasn't as densely populated as it is today, the records show a very thin cheetah population, he says. Now, the cats are much more likely to cross paths with people, livestock and wild dogs that could harm or kill them.

Bettina Wachter, head of the Cheetah Research Project in Namibia, says that even if they were to have access to more prey, the cheetahs would still roam over large distances. Her research has shown that cheetahs spend most of their time at "communication hubs" spread throughout the landscape at 23-kilometre intervals. Learning to avoid these hubs helped Namibian farmers minimise livestock losses.

"Think of it as cheetahs' Facebook, where they go and exchange olfactory [scent] information, they spray urine or faeces, and these are places where they always go back to," says Wachter. They don't change their roaming patterns based on the availability of prey, she says.

"I'm fascinated by the idea of bringing the cheetah back in a science-based manner, but ecologically, that's a very tough goal," says Karanth. Having invested 1.14 billion rupees (\$14.3 million) in the project, India's government will be under pressure to paint it as a success, he says. "They will bring these cheetahs, show them around in zoos and build some tourism around them. It will not lead to a sustained, stable population of cheetahs that can live on its own." ■

INDIA'S ambitious plan to reintroduce cheetahs to the Indian subcontinent, which kicked off on 17 September with the release of eight individuals by Prime Minister Narendra Modi, is unlikely to succeed because the habitat provided is inadequate, scientists warn.

Only around 6500 adult cheetahs are alive today, most of them in Africa, according to the International Union for Conservation of Nature. The Asiatic cheetah (*Acinonyx jubatus venaticus*), a subspecies that is now only found in Iran, went extinct in India in 1952.

Now, the country is introducing the cats to Kuno National Park, an area measuring 748 square kilometres in Madhya Pradesh. Five females and three males from the southeast African cheetah subspecies (*Acinonyx jubatus jubatus*) have so far been relocated from Namibia.

Laurie Marker, executive director of the Cheetah Conservation Fund in Namibia and coordinator of the project, says great care has been taken to ease the cheetahs into their new home. "The cats have been in quarantine for a month [before being brought to India], and they will soon be moved

into an enclosure of about 100 hectares, where they will be able to stretch their muscles," she says.

The plan is to set up a "metapopulation", a small community that survives through the addition of new individuals over time. Based on the amount of prey available, the project designers estimate that Kuno National Park will be able to host 21 cheetahs, or as many as 36 if officials succeed in restoring the

"They will show them around in zoos, but it will not lead to a stable population of cheetahs"

park's periphery. There are 169 villages in the surrounding area, presenting a high risk of conflict between cheetahs and humans.

But according to Ullas Karanth, a former director of the Wildlife Conservation Society's India programme, a viable population requires at least 50 wild cheetahs that are able to independently reproduce. A single cheetah needs a territory of at least 100km² and up to 400km². Karanth estimates that a population of sufficient size to be viable would require an area of 10,000km² to 15,000km².

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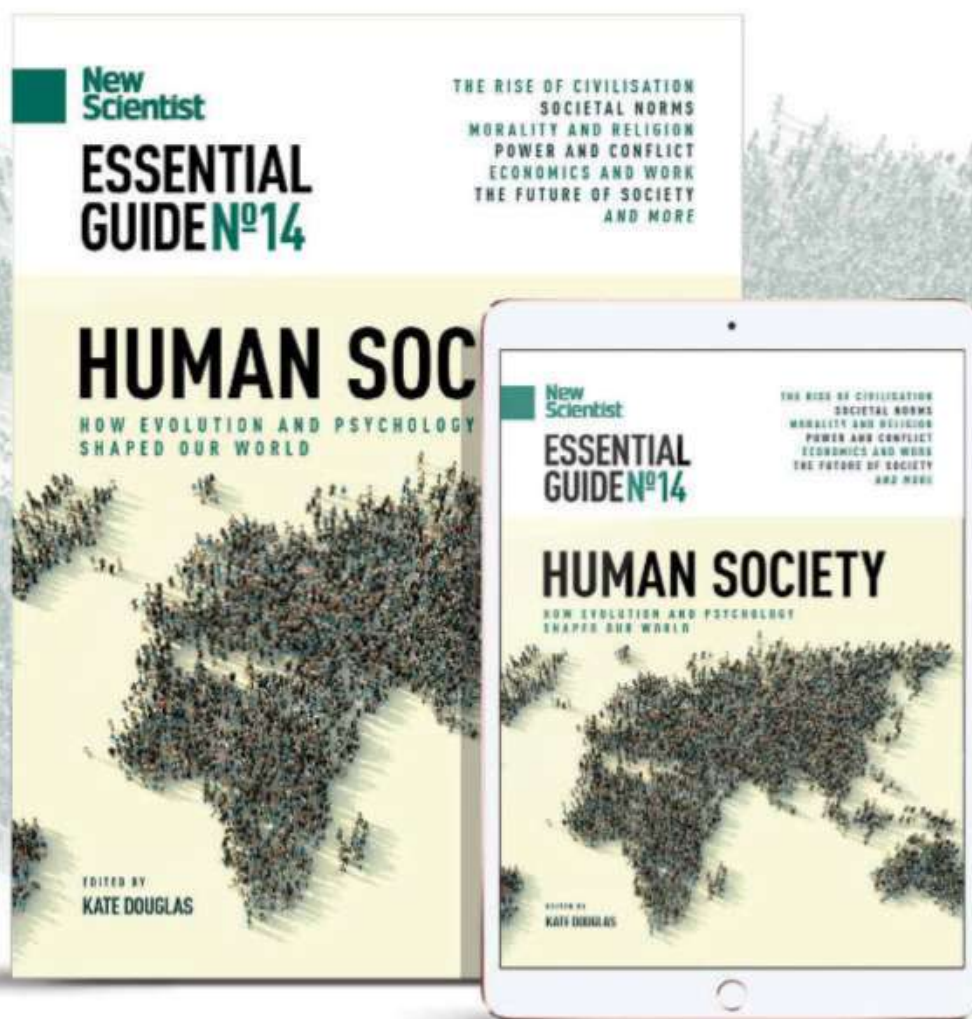
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Solar system

Enceladus has all life's key elements

Reanalysis of icy rock grains has revealed presence of phosphorus from Saturn's moon

Alex Wilkins

SATURN'S moon Enceladus is producing phosphorus, meaning that this icy world holds all the essential building blocks for life as we know it.

Every life form on Earth contains six key elements: carbon, hydrogen, nitrogen, oxygen, phosphorus and sulphur. All of these, bar phosphorus, were already known to exist on Enceladus. This fact, combined with its liquid ocean and warm core, had already made the moon one of the most likely places for life elsewhere in the solar system, if it exists.

However, the lack of phosphorus was thought by some to make life unlikely to exist on icy ocean worlds.

The spacecraft Cassini collected icy rock grains in Saturn's E ring with its Cosmic Dust Analyzer for 13 years from 1999. This ring is thought to be fed by plumes of water ice shot out into space

from Enceladus, which are themselves fed by its oceans. But previous analyses of this material, in 2009, failed to turn up any phosphorus compounds.

"Enceladus now satisfies what is considered one of the strictest requirements for habitability"

Now, Frank Postberg at the Free University of Berlin, Germany, and his colleagues have reanalysed many of these grains with more advanced techniques than previously used and have identified phosphorus molecules.

"Enceladus now satisfies what is generally considered one of the strictest requirements for habitability," Postberg told the Europlanet Science Congress in Granada, Spain, on 20 September.

The original analyses could only look at the average spectra from the grains and didn't have

good spectra of known compounds from lab work to compare their findings against and work out what was in the Cassini grains.

But Postberg and his team have now analysed many more grains individually and compared their spectra with high-resolution ones that have been captured by other research groups in the decade since the first analysis.

Out of the roughly 1000 grains or so they analysed, nine "unmistakably" have the fingerprint of phosphorus – as phosphates – in the form of various salts it forms with sodium, hydrogen and oxygen.

Based on the levels of phosphorus found in the grains, the researchers predict that Enceladus's ocean has relatively high levels of the element. "This is roughly 100 to 1000 times higher compared to the concentration

here in our Earth ocean," Postberg told the conference.

The phosphorus wasn't seen in organic carbon-containing molecules, though. Organic phosphates would be even more beneficial for life, but the resolution of the spectrometer that the researchers used meant they couldn't identify these. However, said Postberg, "it doesn't mean they're not there".

"It seems to be really compelling," says Veronique Vuitton at Grenoble Alpes University in France. "It's so exciting to find phosphorus, for all the obvious habitability reasons."

"Enceladus was already one of the most likely bodies in the solar system with a high habitability potential and this makes it an even stronger case," says Pietro Matteoni at the Free University of Berlin, who wasn't involved with the research. ■

Health

Your gut microbes may affect how ill malaria makes you

THE microbes in your gut may influence how malaria parasites replicate in your body, according to a small study. If confirmed, the findings could mean that altering the gut microbiome can protect people against severe malaria.

Previous studies looking at naturally acquired malaria infections in people have hinted at a possible link between the mix of bacteria in their guts and the severity of the infections.

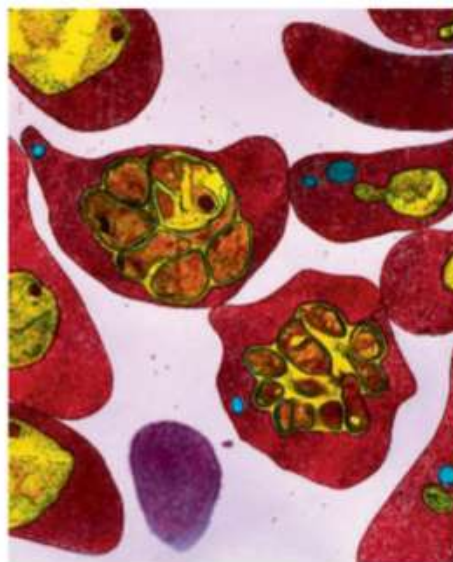
Jennifer Manuzak at Tulane University in Louisiana and her colleagues tested this idea by deliberately infecting people

with *Plasmodium falciparum*, one of the protozoan parasites that cause malaria in humans.

Thirty-five volunteers provided stool samples before allowing themselves to be bitten by mosquitoes carrying *P. falciparum*. The researchers then compared the bacteria in the volunteers' faeces with the parasite levels in their blood at the peak of infection.

People with a microbiome high in *Catenibacterium* and low in *Bifidobacterium* bacteria were grouped into type HC1, while those with high levels of *Streptococcus* and *Bifidobacterium* bacteria were labelled type HC3.

Type HC1 individuals were nearly nine times as likely to have severe parasite levels – defined as a parasite concentration



Malaria parasites (yellow) enter and grow inside red blood cells

microbiome (bioRxiv, doi.org/jdfj).

Manipulating the gut microbiome may become a useful way to reduce the severity of many diseases, including malaria, say Maria Mota and Debanjan Mukherjee at the University of Lisbon in Portugal. However, we don't know how gut microbes might influence the severity of the illness.

One possible mechanism may be through the immune system reacting to sugar molecules that are found on both gut bacteria and *P. falciparum*, says Miguel Soares at the Gulbenkian Institute of Science in Oeiras, Portugal. ■
Carissa Wong

DR GOPAL MURTI/SCIENCE PHOTO LIBRARY

higher than the average across participants – as type HC3 people. On average, levels of *P. falciparum* were nearly six times higher in those with an HC1 microbiome than in people who had an HC3

Physics

Maxwell's demon device could help explain entropy

Leah Crane

AN ENGINE based on a 155-year-old thought experiment has been realised at the largest scale yet, and it may help us understand how entropy, or disorder, is produced. It could also someday be used to harvest energy from motion.

Maxwell's demon is a thought experiment first proposed by Scottish mathematician James Clerk Maxwell in 1867. He imagined a tiny demon sorting gas particles by temperature into two chambers, heating up one and cooling down another. In theory, this temperature differential could drive a perpetual engine, but in practice, it is impossible – it would decrease the amount of entropy in the system, which is forbidden by the second law of thermodynamics.

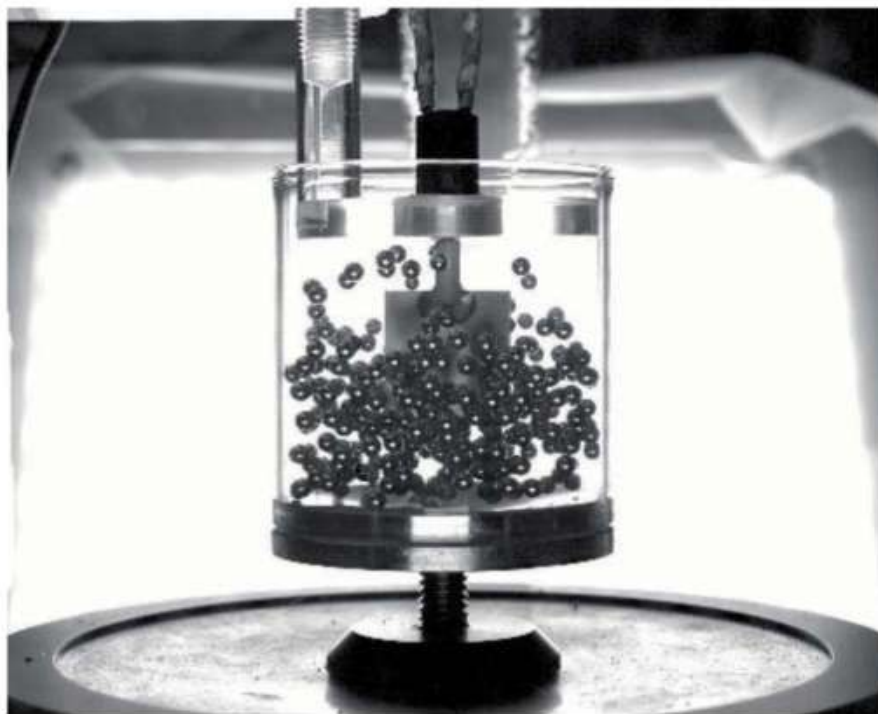
However, physicists now understand that a device similar to Maxwell's demon can be created if you are simply willing to put more energy into the system than you take out of it, which obeys the second law

4

Microwatts of power produced by the small engine

of thermodynamics but means that the demon cannot function as a perpetual engine. Antoine Naert at École Normale Supérieure in Lyon, France, and his colleagues made one such device to see whether it would still work at relatively large scales.

Their device consists of a canister 5 centimetres across sat atop a shaker and containing small stainless steel beads. As the beads bounce about, they act like the particles in a gas, moving randomly around the



ANTOINE NAERT/ENS DE LYON

canister and rebounding off a small rotor. A motor only allows the rotor to spin in one direction. If the beads are pushing it in the allowed direction, it spins and generates an electrical current, and if they are pushing it in the other direction, it stays still. The motor stands in for Maxwell's demon, and without it, the rotor would simply jiggle back and forth randomly (*Physical Review Letters*, doi.org/jdcj).

The electricity to power the shaker is far more than what can be obtained from the rotor's motion, but it isn't hard to imagine a situation where the shaking is provided naturally, such as in a river or on a bridge people are crossing.

"If you have to pay to create this fluctuating environment, then of course it doesn't work – you can't get around the second law of thermodynamics," says John Bechhoefer at Simon Fraser University in Canada, who wasn't involved in this work. "But if someone else gives you this fluctuating environment and you don't

A canister of shaking beads produces energy from motion

have to pay for it, then it could make sense."

This experiment produced only about 4 microwatts of power – tiny compared with the 10 watts required to keep the beads shaking. If this engine could be made larger and the shaking provided for free, the researchers say it could potentially be used to harvest energy from its environment.

It could also be useful in fundamental research, particularly in understanding how information – in this case, information about which direction the rotor is being pushed – is turned into entropy, says Naert.

"If we can measure the information which is exchanged between the 'demon' and the surroundings, then we can measure the entropy creation rate," he says. "The properties of that process are completely unknown, so it's very exciting to explore." ■

Animal behaviour

Tree-hugging lemurs are trying to beat the heat

Richard Kemeny

LEMURS seem to cuddle trees to keep cool on sweltering days.

Chloe Chen-Kraus, affiliated with Yale University, and her colleagues noticed that in the Bezà Mahafaly Special Reserve in south-west Madagascar, a type of lemur called the white sifaka (*Propithecus verreauxi*) hugs the base of tree trunks on particularly hot days.

These lemurs have fewer sweat glands than most primates, so the researchers wondered if this was a way to regulate body temperature.

To learn more, the team watched six groups of sifakas in the hotter part of Madagascar's dry season, noting tree-hugging habits over 615 hours in all. The temperature of the air, ground and trees at several heights was also logged. Over two months, the researchers noted 64 episodes of tree hugging by 20 sifakas in five of the six groups.

The hugging only took place when air temperatures rose above 30°C (86°F). Each 1°C increase then doubled the chance the lemurs would hug trees.

The bases of the trees were up to 5°C cooler than higher parts of the trees and the air, suggesting lemurs embrace the trunks to release some heat (*International Journal of Primatology*, doi.org/jdb7).

This is potentially a very effective way for them to lose heat without relying on evaporative cooling, says Natalie Briscoe at the University of Melbourne, Australia. ■

Tree-hugging lemurs on the Bezà Mahafaly Special Reserve in Madagascar



CHLOE CHEN-KRAUS

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Energy

US grid may buckle under switch to EVs

GROWTH in electric car ownership could strain power grids if most drivers continue chiefly charging at home overnight. Increasing daytime charging will be crucial to help the western US power grid handle the demand with an estimated 50 per cent of drivers using electric vehicles by 2035.

The finding comes from computer models. These found that if drivers primarily charge vehicles at home during the night, that could lead to a 25 per cent surge in peak net electricity demand when states reach 50 per cent electric vehicle ownership, and possibly surpass grid capacity at higher levels of ownership. But more daytime charging facilities could reduce that increase in peak net electricity demand to just 7.5 per cent (*Nature Energy*, doi.org/jdfv). **Jeremy Hsu**



SHUTTERSTOCK/MIA STUDIO

Archaeology

Historical migration dispute looks settled

IN ANGLO-SAXON times, more than three-quarters of the ancestry of people in parts of England came from north European migrants.

The finding may end an ongoing debate about just how much migration there was in this era, from about AD 400 to 1066.

Duncan Sayer at the University of Central Lancashire in Preston, UK, and his team sequenced the DNA of 460 people buried in graves in north-west Europe between AD 200 and 1300, of whom 278 were from England.

This showed that during the 7th century, people buried in the east of England could trace 76 per cent of ancestry to recent migration from Germany, Denmark and the Netherlands. Bodies further west in England had a lower proportion of ancestry from Europe (*Nature*, doi.org/jdfw). **Clare Wilson**

Agriculture

Glimmer of hope in the battle to save the banana

BANANA plants that produce the world's most widely eaten variety of the fruit have been made temporarily resistant to a devastating fungal disease that is spreading around the world and destroying plantations. The hope is that the work could lead to ways to make bananas permanently resistant to this threat.

The main banana exported to Western countries used to be a variety called Gros Michel. But in the 1920s, a strain of *Fusarium* fungus called tropical race 1 (TR1), which causes Panama disease, began wiping out plantations. By the late 1950s, growers had switched to the Cavendish banana, which is highly resistant to TR1.

Now, however, a strain of *Fusarium* called TR4, which can kill many varieties of banana including the Cavendish, is spreading to more and more countries.

Gert Kema at Wageningen University in the Netherlands and his colleagues wondered if exposure to TR1 would protect Cavendish bananas against TR4. The team uprooted young plants and dunked them in a solution containing assorted types of TR1 fungus. At various time intervals from 30 minutes to 10 days later, they then immersed plants in a solution with spores of TR4 in it.

The team found that prior exposure to a particular strain of TR1 from Brazil provided significant protection against TR4 up to 10 days later (*PLoS One*, doi.org/gqvm2h). Kema says the protection is only temporary.

The team is now trying to work out the precise protective mechanism at work, with the aim of finding ways to permanently turn it on in the plants. **Michael Le Page**

Really brief



ALFONSO ALCEVES

Spider catches ants with acrobatic leap

When an ant comes up a tree trunk towards an Australian ant-slayer spider, the spider jumps and attaches a silk line to its prey. It then somersaults over the ant and dangles from the line below it. The spider then circles its victim to entangle it, only moving in for the kill once it is safe (*PNAS*, doi.org/gqt7r8).

Smart face mask could detect viruses

A prototype face mask with a sensor could tell whether someone you are talking to has coronavirus by spotting telltale proteins in their breath. So far, the mask has only been tested on viral surface proteins, not whole viruses, but it can detect those of two flu strains and the virus behind covid-19 (*Matter*, doi.org/gqt2j4).

Drone swarm could build tower blocks

Drones working together can create large 3D-printed structures made of foam or cement. AIs guide their decisions, but they still require human supervision. The experiments pave the way for swarms of drones to construct tall buildings without use of scaffolding or large machinery (*Nature*, doi.org/jdbp).

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SATURDAY
8 OCTOBER



FUTURE STAGE

10.45 - 11.35

AN OCEAN OF SALT

Helen Czerski will explore the great stories of our ocean told through salt.

11.55 - 12.45

THE PATTERN SEEKERS

Simon Baron-Cohen puts forward a bold new theory about humans' remarkable ability to recognise patterns.

13.25 - 14.15

MAKING SENSE OF SCREEN TIME

Pete Etchells will uncover what we really know about the impact of screen time on our mental health, behaviour and sleep.

14.35 - 15.25

HOW TO SPEND A TRILLION DOLLARS

Rowan Hooper conducts the ultimate thought experiment but with a serious message: these are all things we could do, if we put our minds to it – and our money.

15.45 - 16.35

THE BIGGEST NUMBER IN THE WORLD

Join Agnijo Banerjee on an epic quest for unfathomably large numbers.



MIND & BODY STAGE

10.45 - 11.35

THE DARK HISTORY AND TROUBLING PRESENT OF EUGENICS

Adam Rutherford will tell the story of the pseudoscience of eugenics.

11.55 - 12.45

A BRIEF HISTORY OF YOUR BRAIN

Emma Byrne reveals how our brains change over the course of childhood and beyond.

13.25 - 14.15

THE SECRET BODY

Daniel Davis will discuss the ground-breaking scientific quest to understand the human immune system.

14.35 - 15.25

BELIEVING THE UNBELIEVABLE: THE SCIENCE OF PARANOIA AND CONSPIRACY THINKING

Nichola Raihani presents an evolutionary perspective to illuminate the logic – and even the benefits – of paranoia.

15.45 - 16.35

REBEL CELL: A NEW VIEW OF AN OLD DISEASE

Kat Arney will take us to the dawn of life on planet Earth right up to the present day to get to the heart of what cancer really is.



OUR PLANET STAGE

10.45 - 11.35

HAND TO MOUTH: THE LANGUAGE PUZZLE

Gillian Forrester will explore a leading theory behind the emergence of modern human language.

11.55 - 12.45

NOMAD CENTURY: THE GREAT CLIMATE UPHEAVAL

Gaia Vince will describe how we can use managed climate migration for our survival while we restore the planet's habitability.

13.25 - 14.15

WONDERDOG! HOW WE CAME TO KNOW THAT DOGS ARE SO SMART

What do dogs really think of us? Jules Howard will reveal the latest research into 'dognition'.

14.35 - 15.25

WHY WASPS MATTER

Seirian Sumner will journey into the secret world of wasps, guaranteed to blow your mind.

15.45 - 16.35

THE SECRET LIVES OF ANIMALS

Lizzie Daly takes you on a journey following in the footprints of wildlife from across the world.



UNIVERSE STAGE

10.45 - 11.35

THE HIDDEN SCIENCE OF WEATHER, CLIMATE CHANGE AND THE AIR THAT SURROUNDS US

Simon Clark introduces the fascinating story of our atmosphere.

11.55 - 12.45

THE JOY OF ABSTRACTION

Eugenia Cheng will show how even high-level abstract maths can be accessible, open-ended, and joyful.

13.25 - 14.15

THE HIDDEN UNIVERSE

Emma Osborne will take you on a gravitational wave journey from creation to detection, and the remarkable discoveries that are beginning to reveal the hidden universe.

14.35 - 15.25

ELUSIVE: THE STORY OF PETER HIGGS AND HIS BOSON

Frank Close will examine the life of Peter Higgs, and his eponymous boson.

15.45 - 16.35

BLACK HOLES

Jeff Forshaw reveals the complex quantum problems that emerge when trying to track information flowing in and out of black holes.

SUNDAY
9 OCTOBER



FUTURE STAGE

10.45 - 11.35

THE FUTURE OF UK SCIENCE AND INNOVATION

Sir Patrick Vallance outlines the case for why science in government matters.

11.55 - 12.45

A WORLD-RECORD BREAKING ATTEMPT TO CREATE STAR POWER

Joe Miles will tell the story of the world's largest operating fusion energy machine, the Joint European Torus.

13.25 - 14.15

THE GEOLOGICAL RECORD OF CLIMATE CHANGE

Chris Jackson will look at how the geological record of climate change can help us better understand our present and future climate.

14.35 - 15.25

MATHEMATICS IS OUR SUPERPOWER

Junaid Mubeen will take us on a fascinating exploration of a surprising advantage that humans have over artificially intelligent robots.

15.45 - 16.35

CAN SCIENCE SAVE THE WORLD?

Lord Rees will argue that science is not just for scientists. We all need to be involved in the decisions which will shape our future.



MIND & BODY STAGE

10.45 - 11.35

ULTRA-PROCESSED FOOD

Chris and Xand van Tulleken reveal the truth about what ultra-processed foods do to our bodies.

11.55 - 12.45

CAN FISH COUNT?

Brian Butterworth will propose a scientific definition of counting and describe evidence showing how animals from fish to insects can count.

13.25 - 14.15

THE HUMAN BODY: DESIGN DISASTER

Cardiologist and comedian Dr Rohin Francis will explore just some of the myriad ways there's nothing Intelligent about our Design.

14.35 - 15.25

DNA FAMILY SECRETS

Turi King will chart the rise in the use of DNA in genealogy and forensics for everything from tracing long lost family members to catching criminals.

15.45 - 16.35

THE BODY AND SELF- CONSCIOUSNESS

Moheb Costandi uncovers the latest research into how our brains perceive our bodies.



OUR PLANET STAGE

10.45 - 11.35

THE DEEP CHEMISTRY OF LIFE AND DEATH

Nick Lane will describe the Krebs cycle – a series of reactions that transform inorganic molecules into the building blocks of life.

11.55 - 12.45

EXPLORING THE DEEP SEA

Marine biologist Helen Scales will tell the story of our relationship with the deep sea.

13.25 - 14.15

IT'S NOT EASY BEING GREEN

Julia Cooke and Yoseph Araya reveal fascinating stories about how plants survive, from the poles to the tropics and the seas.

14.35 - 15.25

THE EARTH: A BIOGRAPHY OF A LIVING PLANET

Elsa Panciroli explores some of the incredible organisms that have lived and continue to thrive in our world.

15.45 - 16.35

NEANDERTHALS: EXPLORING COMPLEX MINDS

Rebecca Wragg Sykes will reveal the latest research into Neanderthals; how they lived, thought and died.



UNIVERSE STAGE

10.45 - 11.35

THE DARK UNIVERSE: SEEING THE INVISIBLE

Alexandra Amon will look at why cosmology 'needs' dark matter and how astrophysicists are learning more about what it is.

11.55 - 12.45

A NEW FORCE OF NATURE?

Harry Cliff will reveal the growing evidence for a new force of nature, through recent data from the LHC and Fermilab.

13.25 - 14.15

EXPLORING OCEAN WORLDS

In this talk Emma Bunce will explore the methods for detecting the oceans on the icy moons in our solar system.

14.35 - 15.25

THE SCIENCE OF EXPLODING STARS

Or Graur will be your guide to the awe-inspiring astronomical phenomena of supernovae.

15.45 - 16.35

PHYSICS EXPERIMENTS THAT CHANGED THE WORLD

Suzie Sheehy will uncover how our curiosity-driven determination to understand the microscopic brought about a revolution in physics.

ENGAGE STAGE

SATURDAY
8 OCTOBER

10.45 - 11.30

HOW I HACKED MY WAY INTO SPACE

Join J Spooner of the Unlimited Space Agency as they tell the inspirational story of a 42 year old person's creative adventure to hack their way into space.



11.40 - 12.00

NEGLECTED TROPICAL DISEASES AND WHERE TO FIND THEM

Join Poppy Lamberton, in conversation with host Emily Bates, to find out how her and her team are working to control neglected tropical diseases.

12.00 - 12.40

EXPLORING DEEP OCEANS WITH GHISLAIN BARDOUT

Join ocean explorer Ghislain Bardout, in conversation with host Emily Bates, to hear about how we all have a part to play in preserving our seas.

12.40 - 13.00

OUTSMARTING HEART DISEASE

Join experts from the British Heart Foundation to hear how the latest research is tackling heart disease.

13.25 - 14.10

LIVE FROM THE SPACE SHED: BRAINS WITH EMMA BYRNE

J Spooner returns with special guest Emma Byrne for a chat about all things cerebral.

14.20 - 14.40

GILLIAN FORRESTER: WHY ARE HUMANS THE ONLY TALKING APES?

Cognitive scientist Gillian Forrester discusses her pioneering research into how humans learnt to talk.

14.40 - 15.00

THE WONDER OF DOGS WITH JULES HOWARD

Join author and dog cognition expert Jules Howard, in conversation with Emily Bates, for a lively chat about all things canine.

15.00 - 15.20

HOW TO BECOME A YOUTUBE SCIENTIST WITH DR SIMON CLARK

Join host Emily Bates as she chats to physicist Simon Clark about being one of the UK's most popular science YouTubers.

16.00 - 17.00

NEW SCIENTIST JOURNALISTS: ASK US ANYTHING!

Put your questions to our team of amazing science journalists.

SUNDAY
9 OCTOBER

10.45 - 11.30

LIVE FROM THE SPACE SHED WITH DALLAS CAMPBELL

Join TV presenter and space superfan Dallas Campbell for a lively conversation about humanity's attempts to leave the planet.

11.40 - 12.20

FECAL MICROBIOTA TRANSPLANTATION: FROM BENCH TO BEDSIDE AND BEYOND

Join Blair Merrick as he explains how transplanting stools from healthy to ill people is a potentially lifesaving treatment for a host of conditions.

12.20 - 12.40

TALKING TOXOPLASMA: THE PARASITE THAT GETS EVERYWHERE!

Join Lilach Sheiner and Clare Harding as they reveal the amazing life of *Toxoplasma gondii*.

12.40 - 13.00

OUTSMARTING HEART DISEASE

Join experts from the British Heart Foundation to hear how the latest research is tackling heart disease.



13.25 - 14.10

MAPPING THE UNIVERSE WITH ALEXANDRA AMON

Join J Spooner as they get cosmological with amazing astrophysicist Alexandra Amon.

14.20 - 14.40

GEOLOGY ROCKS, WITH CHRIS JACKSON

Join geologist Chris Jackson to explore why we should look underground to understand our future.



15.00 - 16.00

NEW SCIENTIST JOURNALISTS: ASK US ANYTHING!

Put your questions to our team of amazing science journalists.

16.00 - 17.00

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The columnist
Chanda Prescod-Weinstein on the pace of research **p28**

Aperture
Aerial photos show Africa transformed by industry **p30**

Letters
Should we be trying to return humans to the moon? **p32**

Culture
Digital doubles take to the stage in dance piece *Anti-Body* **p34**

Culture columnist
Brothers battle to save raptors in Delhi, finds Simon Ings **p36**

Comment

Snouting around

Keystone species such as wild boar may be far better conservationists than humans. We must cherish them, says **Benedict Macdonald**

WELCOME to some uncomfortable truths: keystone species were managing the planet quite well for millions of years before humans ever got involved, and wild boar may be considerably better conservationists and foresters than we are.

In recent decades, we have seen great breakthroughs in the study of wild animals. But when I began writing *Cornerstones*, a book about how keystone species such as beavers, eagles and lynx once helped to shape Britain's ecology, one thing became clear. While there are many studies of animals as organisms within a landscape, we appear far more reluctant to admit that some animals profoundly enhance the habitats in which they live.

Boar, as I found in my 10-year study in the Forest of Dean, act as nature's excavators, but are possessed of an ecological finesse few credit them with. By "rootling" soil – turning it over in search of tubers, invertebrates and other subterranean goodies – boar "rotavate" and reset the soil biome. This aerates it, exposes it to a new generation of plant and tree seeds and creates complex microhabitats, including ponds, grassland glades and bare earth – the basis of new floral life.

If you walk through a once-pristine glade of bluebells in the Forest of Dean, it might appear upsetting – destructive, even – that, in the dead of night, an army of nocturnal diggers have arrived



and caused chaos. The uneven soil, disrupted bulbs, broken flowers and smashed bracken don't look like the work of an animal possessed of ecological genius.

The robins and blackbirds, however, have already cottoned on. If you sit and quietly watch the exposed ground, called a "boar digging", you will begin to see a procession of birds, always robins first, following in the boar's wake because their actions have exposed vital earthy areas where the birds can find worms. After all, why do you think robins follow disruptive primates with hoes around their gardens?

Boar may be forest gardeners, but no garden looks its best on day one. Like any ecological process, it takes time. That said, within a few months of rootling, the new soil will already have been colonised. Dog violets can appear the spring after, bringing in their wake colonies of small, pearl-bordered fritillary butterflies. Yet it may be as many as three years later that green-winged orchids appear in profusion, in the same boar digging, alongside foxgloves buzzing with solitary bees.

By opening up the soil, boar pave the way for many outcomes that ecologists could only

appreciate if they returned to the same site year on year. Small depressions where boar have wallowed turn into vital ponds, which are rich spawning grounds for frogs. Rotavated areas of soil come to burst with wild mint and bramble, which, in turn, bring pollen resources into the forest, attracting hoverflies, bees and butterflies like the white admiral.

Eventually, these same diggings begin to sprout with trees, as blackthorn, hawthorn or hazel push up from them, so beginning a whole new forest generation. It doesn't stop there. Boar are one of very few mammals able to carry large tree seeds – such as wild crab apple – in their guts and then excrete them, intact, complete with a healthy dose of fertiliser.

Ecologists and scientists aren't without ego. It can be hard to accept that an animal "snouting" around to find food can not only create habitats for rare orchids, butterflies, fruit trees and frogs, but may also be far better at carrying out all these processes than we are. But given boar do this, and did it before us, then what is our role? Well, as the steward of stewards, my argument would be that we must cherish and protect keystone species like them. Then, we will become the greatest keystone species of them all. ■



Benedict Macdonald is a conservationist and author of *Cornerstones*

Field notes from space-time

On a cosmic schedule I work on the dark matter problem knowing it may be solved long after I die. The universe doesn't cater to human timelines, says **Chanda Prescod-Weinstein**



Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading

I am loving Elizabeth Crane's divorce memoir This Story Will Change: After the happily ever after.

What I'm watching

I have been rewatching Star Trek: Discovery, which is even better the second time!

What I'm working on

I have begun to work out the concept for my next book.

IT HAS been almost a century since Fritz Zwicky first hypothesised the existence of *dunkle materie* – which translates to “dark matter” in English. In 1933, looking at observations of galaxy clusters, he noted that there seemed to be a mismatch between the mass indicated by the motions of the galaxies and the mass measured by how much light the galaxies were radiating.

About 30 years later, Vera Rubin and Kent Ford used observations of stars orbiting their galactic centres to truly substantiate this mystery: there was more matter than we could see, suggesting a kind of invisible particle was actually dominating the motions of visible particles. Rubin and Ford's papers on this topic were published over the 1970s, leading to an awakening in the 1980s: the dark matter problem was real, and it wasn't going anywhere.

These timescales are large compared with a human lifetime. Having just turned 40, I still feel like 10 years is a long time! But 30 years is about half of many human lifetimes, and it was long enough that Zwicky didn't get to see all of Rubin and Ford's papers be published – he died in 1974. He didn't live to see his hypothesis blossom into a major field of research.

The universe – beyond those close to Zwicky or superfans of his work – doesn't care that he couldn't witness dark matter become a compelling area of research. But, ultimately, we humans are the only part of the cosmos to care about the schedule on which we understand its details, and sometimes we get very emotionally invested in this process.

As a teenager, I read a book by Dennis Overbye – *Lonely Hearts of the Cosmos* – that featured Zwicky

as one of many people involved in a dramatic debate about another cosmic mystery. This particular conundrum – how to measure how fast space-time is expanding – began with Edwin Hubble's first measurements in the late 1920s and continues to this day.

In fact, the “Hubble tension”, as the discrepancy between our measurements of this is now known, has been one of the hottest topics in observational cosmology in the past few years. It is a bit of a rabbit hole, too: every time we think we have answers, we get more questions. In 1998, two different teams realised the

“This is the nature of science: we think we know something, then our understanding is transformed”

expansion of space-time was speeding up. So the problem is now different to the one Hubble thought he had identified in 1929.

This is the nature of science, at least in the realm of particle physics and cosmology. We think we know something, then our understanding is transformed by new information. We get new, interesting findings when we get them, which isn't always when we want to get them. The cosmos, on the whole, doesn't cater to our personal interests or timelines. We are the only part of the cosmos to do that.

This is personal for me. I work on the dark matter problem, and I do that daily while knowing that the questions I have may well be answered the day after I die. Or 200 years after I die. My personal timeline is, in many ways, irrelevant to when we humans work out the right model

or get the right data. I try not to get emotional about this. This is the life I signed up for: to think about interesting ideas and hopefully find out whether any of them are correct. Emphasis on hopefully.

In particle physics, we got a bit spoiled during the 20th century. There are people older than me who came of age at a time when there were new particle physics discoveries, it seemed, every few years. A piece of data led someone to hypothesise a model with a new particle in it. People went looking for the particle, and they found the particle.

There are also people my age and younger who were raised on stories of these discoveries, with the promise that when we were older, we would experience a similar journey in science. As recently as 2012, we actually did, with the direct measurement of the mass of the Higgs boson. But the last major excitement before that was with the top quark in 1995 (if we aren't counting dark energy, which we should, but I digress). It had been a while – if we are using an academic lifetime as our unit of measurement. And in 2022, we haven't seen anything new.

Some people will have you believe this means particle physicists are wasting our time pushing forward using techniques that we know have worked in the past. “They just make things up for a living!” they say, as if this is a bad thing. But I love this creative element of science, and it has been a historically important feature of the process.

In a time of rising fascism, I think it is important to be humble and embrace our creative side. There is so much we don't know about the cosmos, and as Carl Sagan once said, without imagination, we go nowhere. ■

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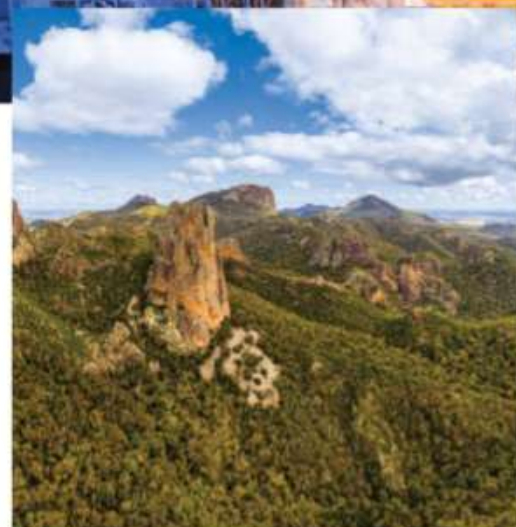
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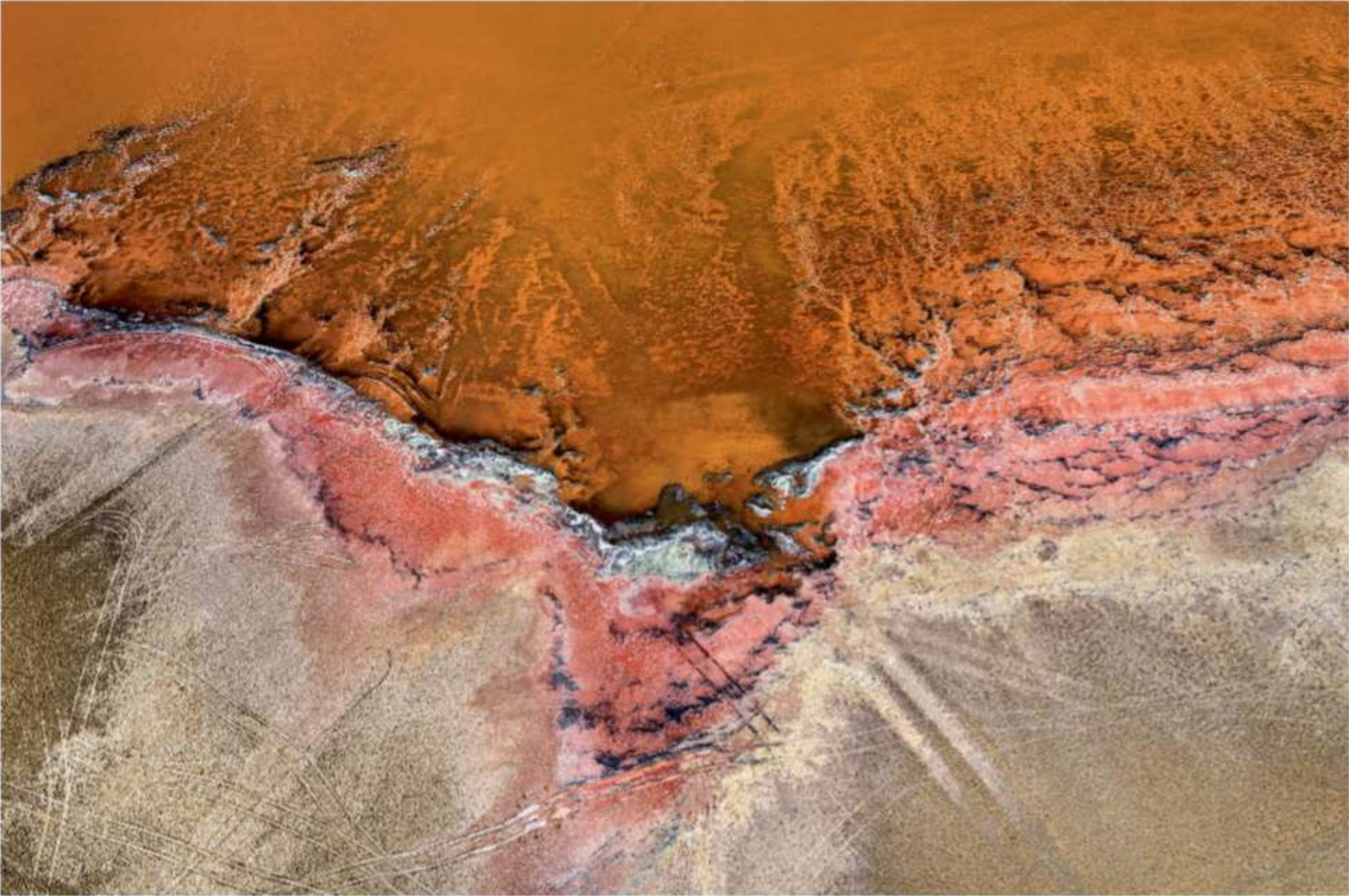
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Salt of the Earth



Photographer **Edward Burtynsky**
Gallery **Flowers Gallery, London**

AFRICA has played a significant role in our species' history and development, and is where the first humans emerged. Today, thanks to an abundance of untapped resources, this giant continent is on the cusp of becoming the next major industrial hotspot – but the appetite for economic growth is also propelling resource depletion.

These arresting images illustrate the scale of this change, and are taken from the upcoming photography book *African Studies*, by artist and photographer Edward Burtynsky, who spent four years capturing the landscapes of sub-Saharan Africa, mainly using drones and taking photographs from aircraft. "Africa... now stands as a final destination for the complex arc of globalism," he says.

The top images show two saltworks in Senegal, the largest producer of salt in West Africa. Salt water from nearby canals trickles into these human-made ponds near Naglou Sam Sam (top left) and Tikat Banguel (top right), before evaporating to leave the salt behind. The ponds' brilliant hues are due to minerals, pigments and algae that colour the water differently depending on salinity.

Namibia is another of Africa's salt suppliers, with a saltworks in Swakopmund shown at bottom left. The image to its right is the Sishen iron ore mine near the town of Kathu in South Africa, one of the world's largest producers of this material, which is primarily used to make steel.

Burtynsky's images will be exhibited at the Flowers Gallery in London from 14 October to 19 November. ■

Gege Li

Editor's pick

Should humans be returning to the moon?

17 September, p 38

From Nick Burke, Portland, Oregon, US

Sending people to the moon always seemed misguided. Space agencies could have flooded the solar system with hundreds of probes, rather than operating expensive crewed missions to space that make only narrow discoveries.

For example, there are seven other substantial planetary atmospheres that should be utterly surrounded by weather satellites. This would increase meteorological knowledge, vital for our climate crisis. Also, the most habitable places in the solar system other than Earth are the oceans on some of the moons of the outer planets. We should already know if life is found there.

Spaceflight is hard. Small populations of isolated people sparsely scattered in nearby parts of the galaxy thousands of years from now might be plausible. But science fantasy has misled humanity and raised the perceived benefits of crewed programmes above today's realities. Current priorities should be reversed: space science, not space engineering, has the greater return.

From Philip Stewart, Oxford, UK

It is beyond belief that we are talking of sending humans back to the moon. Have we forgotten the general loss of interest in 1972? There is now increased awareness of the dilapidated state of Earth, the huge cost of sustaining settlers on other celestial bodies and the fact that returns on such huge investments are likely to be meagre. These are just vanity projects.

From Keith Davis,

Kinver, Staffordshire, UK

I propose the use of a "mooncrete", comprising a mixture of lunar regolith – or moon dust – water and hydrogel, as a material from which to build a lunar base.

Moon dust is notoriously gritty stuff, composed of microscopic

fragments of pulverised rock. The function of the hydrogel would be to lock those spiky particles into place and fill the voids between them, thereby reducing the porosity. As a building material, it would have the desirable property of being readily recyclable, should the need arise to reconfigure the layout of a base, for example.

Risk of illness puts me off swimming in wild water

17 September, p 25

From Julius Hogben, London, UK

"Come on in, the water's cold" briefly raised the issue of water quality for anyone swimming wild, but needed to go further.

A report by UK group Surfers Against Sewage in May included a survey of 2000 people that found over half of those who went wild swimming last year, or tried water sports in British seas and rivers, fell ill from pollution. It sure puts me off. More than half of the respondents were clear that improvements to reduce sewage pollution should come from the water companies' profits.

On the mystery of higher death rates in parts of UK

10 September, p 14

From David Fremlin, Colchester, Essex, UK

Your graph showed there have been more deaths than usual in England and Wales up to 5 August. The figures before 15 April were consistently low, and since then have been consistently high. My own analysis suggests that this has continued.

You proposed some reasons, such as issues in health services, but none can account for the uniform difference between the periods before and after mid-April.

There was, however, a striking change in behaviour around that time. People began to travel much more. There was a greater willingness to meet in groups indoors and a rapid decline in elementary precautions against covid-19, such as wearing masks when shopping. I haven't seen any convincing account of the relative importance of these precautions, but the sum of them seems to have been about 1000 deaths a week.

Figuring out chronic fatigue is never easy

10 September, p 42

From Shaun Phillips, Bilston, Midlothian, UK

I enjoyed your article "Figuring out fatigue". As an academic who researches fatigue from a sport and exercise perspective, I appreciate how complex it is to conceptualise. You focused heavily on sensing of energy availability as the driver behind fatigue development, but there is copious evidence in the sport and exercise sciences of acute and chronic fatigue, though not in the clinical definition, in the presence of an abundance of cellular energy.

From Stephanie Woodcock,

Carnon Downs, Cornwall, UK

An anti-inflammatory strategy to tackle fatigue might be risky in some cases. Maybe the body is right and is doing its best to counter a very clever pathogen that has so far eluded discovery.

I acknowledge that short-term treatment to defuse major inflammation must sometimes be done. However, trying to negate the body's attempt to defend itself while it faces a little-understood chronic illness, simply by relying on the presumption that it is wrong, could be a mistake.

To shift the climate needle we must rethink message

10 September, p 27

From Steph Györy, Sydney, Australia

The case for "longtermism" – caring about future generations and the environment – wouldn't need to be made if we raised all children to accept they belong to an interdependent species that is part of a global biosphere with a shared, billions-of-years-old lineage connected through DNA – and aren't, as humans, somehow chosen or special.

In making his case, the author of the article, William MacAskill, invokes a moral argument. This approach is unhelpful because it makes it easy to attribute blame and difficult to find the root cause of behaviours, let alone win people over.

Drought and fire cast doubt on offsetting

17 September, p 13

From Alex Wilks, Bristol, UK

You report an expert warning of a "cascade of tree mortality" caused by drought in Europe. The claims of many schemes to offset carbon emissions by planting trees were already controversial. These findings about the impacts of drought, plus the rise of large forest fires in many regions of the world, make it even clearer that planting trees is a palliative, not a cure, for climate change.

There is no substitute for cutting fossil fuel emissions and halting deforestation.

It is time to rethink the equation for BMI

10 September, p 28

From Larry Stoter,

The Narth, Monmouthshire, UK

Body mass index – weight divided by height squared – has always seemed questionable to me. Wouldn't weight divided by height cubed, a rough measurement of density, be better? ■



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Dancing towards a new future?

Who will we become in a transhuman world? A new dance work uses motion capture and beguiling visuals to explore further, says **Alexandra Thompson**



Dance

Anti-Body

Alexander Whitley Dance Company
Lilian Baylis Studio, Sadler's Wells
Theatre, London, from 6 to 8 October

IN HIS book *Homo Deus*, writer Yuval Noah Harari asks: "Are organisms just algorithms and is life just data processing?" Is it possible that the human mind could one day be downloaded onto a computer chip?

This existential, unsettling idea is key to *Anti-Body*, a new dance work from the Alexander Whitley Dance Company, which has its London premiere next week.

At a recent technical rehearsal, I saw the piece's three dancers standing behind screens. Motion-capture sensors strapped to their bodies pick up their routines and the movement data is transmitted to a computer.

The technology, more commonly used in video games, creates a series of visuals on the screens. These range from 3D cell-like images to human avatars, all shifting in real time in response to the dancers' movements. It is stunning and technologically impressive, with nothing pre-recorded – should a dancer trip, the images will also take a tumble.

The dancers' control of the visuals is a nod to our increasing reliance on technology and how this blurs the line between the physical and digital worlds. "Our actions take effect far beyond the immediate presence of our bodies," explains Alexander Whitley, the work's choreographer and artistic director.

With billions of us keeping a smartphone semi-permanently in our back pocket (or at least within easy reach), the internet is always on hand to answer our queries or



The "dancing" visuals in *Anti-Body* are created by motion-capture tech

project, but the message may get a little lost in translation, with no dialogue or subtitles to guide the audience. But what I saw was a rehearsal, and I was told the show may open with a passage from *Homo Deus* (though not necessarily the one I cited above) to help set the scene.

Whitley, however, is unfazed by the prospect that the audience will set about making their own interpretation of his dance piece. "There will always be ambiguity in interpretation when working through dance," he says.

While the dancing is obviously impressive, the movements are less showy and technically demanding than those you would typically find in a traditional ballet or modern dance performance.

Perhaps Whitley isn't really that concerned with showing off his choreography credentials by putting his dancers through their paces. After all, if the simplicity of the movements lets the screen visuals do the work, Whitley is then free to concentrate on conveying his messages.

So, if next week's audiences have modern and adventurous tastes, they should enjoy the choreography. But the big draw for many will be the piece's technological feats. I found myself drawn to the "dancing" visuals more than to the talented physical dancers themselves.

As for what *Anti-Body* means, it will take someone with a vivid imagination (or deep knowledge of post-human theory) to walk away with a new take on transhumanism or how the digital world will impinge on their life. As a more traditional dance fan, I think I will stick to *Swan Lake*. ■

sate our appetite for information. Who or what are we becoming, asks Whitley, in a hybrid, post-human, real/virtual world?

His dance company has turned to science and technology before through works like *Uncanny Valley*,

"Anti-Body is concerned with discovering what motion capture can offer art, creativity and self-expression"

drawing on the idea from robotics that objects appearing almost, but not quite, like humans produce feelings of eeriness in us all.

Then there was *8 Minutes*, named after the time it takes for light from the sun to reach Earth, which explored the possibility of explaining advanced

concepts through movement.

The way technology reshapes our world may be unsettling, but *Anti-Body* feels more positive than that, concerned with discovering what motion capture and other emerging methods can offer art, creativity and self-expression.

Whitley says he also wants to explore the way the dancers' movements influence the visuals produced on the screens: for him, the show is about what motivates people to think about living beyond the material confines of the body. Welcome to the transhuman.

In one routine, a dancer remotely controls two cell-like images that appear on one screen. The visuals evolve as the cells are replaced by increasingly human-like avatars.

Anti-Body is an ambitious

Rare seeds of hope

As agriculture becomes more industrialised, saving unusual vegetables from extinction is vital, finds **Chris Stokel-Walker**



Book

The Seed Detective

Adam Alexander

Chelsea Green Publishing

CATAclysmic headlines about food shortages, broken supply chains and overwhelming heat in the past few months have brought more awareness of where our food comes from. But decades of industrialisation of production have ensured we are still relatively detached from what we eat.

Award-winning film and TV producer Adam Alexander wants to fix that, as he makes clear in his book *The Seed Detective: Uncovering the secret histories of remarkable vegetables*.

While Alexander's day job involves producing documentaries, his other passion is collecting seeds from around the world. He is one of a number of dedicated enthusiasts looking to uncover and conserve the seeds of edible plants that are feared to be on the edge of extinction.

Alexander isn't focused on the

Adam Alexander seeks out unusual seeds in Luang Prabang market, Laos

standard range of vegetables and their varieties usually stocked on supermarket shelves – flavourless, listless tomatoes and watery, pap-like cucumbers – but on rarer or more ancient varieties that have been pushed to the fringes, from the tomato *Solanum pimpinellifolium* to the Stenner runner bean, which was first grown by Brython Stenner in his garden in the 1970s.

One of the author's bugbears is the branding of unusually coloured tomatoes and carrots on upscale restaurant menus, or in plastic packs on supermarket shelves, as "heritage" or "heirloom". They are often nothing of the sort, he says, but are modern hybrids designed to look a little different.

His fascination started with a sweet and spicy pepper he ate on a trip to Ukraine. It was unlike any he had tried before, and it helped him develop his sixth sense for seeking out unusual fruits and vegetables – and their seeds. Rather than be drawn in by colourful varieties or bombastic backstories, Alexander seeks proprietors of market stalls, assuming – usually correctly – that they are growing the oldest, most reliable, least mainstream varieties.

While Alexander doesn't limit himself to the crops most amateur

gardeners will know, he does delve deep into the cultural history of common plants and vegetables, puncturing the myths around them (no, carrots weren't bred to be orange to honour the Dutch royal family), while providing new insight into things we take for granted.

Take lettuce. In an early chapter, Alexander explains how the tasteless, ubiquitous iceberg lettuce came to be, starting with the Great Lakes iceberg, which was designed to withstand a cross-country train ride. But there are rarer lettuces we should try: his suggestions include bloody warrior, Bunyard's matchless and Amish deer tongue.

Each chapter takes a theme, focusing either on a specific fruit or vegetable, or on a broader family of plants, looking at their history and telling of how Alexander has hunted down the rarest seeds. The writing is rich, demonstrating his deep integration into the world of seed seekers. He is a board member of Garden Organic, a UK gardening charity, and a seed guardian for the Heritage Seed Library, which asks growers worldwide to distribute, grow and propagate seeds in order to ensure their continued survival.

Alexander argues that we should delve deeper into the more obscure varieties due to their importance in maintaining global crop diversity. Ninety per cent of all fruit and vegetable varieties, he writes, have been lost in the past century as production has become ever more mechanised and standardised.

It is a clarion call to think about our food in new ways and to carefully consider where it comes from. "We are now, I hope, on a journey back to a more meaningful relationship with our soil, our seeds and our produce," says Alexander. "Long may it continue." ■

Chris Stokel-Walker is a technology writer based in Newcastle, UK

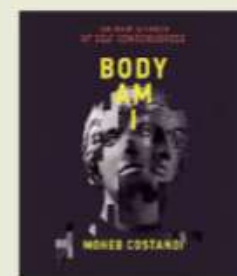
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invites you to board an imaginary spaceship to explore an unknown planet, guided by an alien AI. Blast off from 6 October at the Science Museum in London.



Read

Body Am I declares neuroscientist Moheb Costandi, whose stories of phantom limbs, rubber hands and other phenomena reveal the central role bodily awareness plays in how we establish a sense of identity. Out on 4 October.



Read

Night Terrors is creative writing lecturer Alice Vernon's deep dive into the history, science and culture of sleep disorders, or parasomnias, as well as a confrontation of her own troubled nights. Published on 6 October.



JULIA ALEXANDER

The film column

Really in it together In *All That Breathes*, a compelling documentary set in Delhi, humans are just another animal – alongside pigs, black kites, rats, mosquitoes and millipedes – struggling to survive during a global emergency, finds **Simon Ings**



Simon Ings is a novelist and science writer. Follow him on Instagram @simon_ings



Salik Rehman and one of the injured birds he works to save

bare centimetres off the ground, a fascinating, complex world is revealed. Later, we hear that Hindu nationalists are linking Delhi's Muslim population with disease and poor hygiene. Those with any historical sense will know where this thinking can lead.

Whether or not one picks up on all the film's nested ironies is left to the viewer. Sen's method isn't to present an argument, but rather to get us to see things in a new way. Of the film's black kites, Sen has said: "I want audiences to leave the theatre and immediately look up."

Achieving this requires a certain artifice. We may wonder how a tortoise can reach the top of a pile of rubbish just in time to watch a motorbike career around a distant corner. The human conversations are also somewhat problematic. After watching so many handheld documentaries, I found them a bit too on-message, a bit too polished.

But why cavil at such a powerful and insightful film? Filmed in 2020 and 2021 by cinematographers Ben Bernhard, Riju Das and Saumyananda Sahi, *All That Breathes* inhales extreme close-ups and cramped interiors, and exhales vertiginous skyscapes and city skylines.

The story of Delhi's black kites, often injured by the glass-coated threads used to fly and battle paper kites – one of Delhi's most popular pastimes – might have been better served by a more straightforward story. But then they would have become a small, even inconsequential problem.

The whole point of Sen's film is that the kites are a bellwether. We are all in this emergency together, struggling to fly, struggling to breathe. ■



Film

All That Breathes

Shaunak Sen

In UK cinemas from 14 October

Simon also recommends...

Book

The Great Derangement

Amitav Ghosh

University of Chicago Press

A book packed with original insights traces the accidents of literary history that have made it all but impossible to write good literature about the climate emergency.

Film

Kes

Ken Loach

Based on the novel *A Kestrel for a Knave* by Barry Hines, this film tells the story of a working class boy who finds a life worth living when he adopts a fledgling kestrel.

"HUNDREDS of birds are falling out of the sky every day," says Nadeem Shehzad, by far the grumpier of two brothers whose life's work is to rescue the injured raptors and water birds of Delhi. "What amazes me is that people go on as if everything's normal."

In Shaunak Sen's *All That Breathes*, which won a Grand Jury prize at this year's Sundance Film Festival, people aren't the only ones making the best of things under Delhi's polluted skies. The city is also home to rats, pigs, frogs, mosquitoes, turtles, cows, horses and birds, especially black kites, which have now replaced vultures as the city's chief recycling service, cleaning up after its many slaughterhouses and meat-processing plants.

The film follows Nadeem, his brother Mohammad Saud and their young cousin Salik Rehman as they struggle to turn their family obsession into a wildlife hospital at their home. No sooner is another funding bid completed than their meat mincer for kite food breaks down. No sooner is a wounded bird stitched up than

there is a power cut. What happens to the family's sewer connection when the monsoon arrives doesn't even bear discussing.

These struggles are compelling, and yet this isn't really a film about humans. It is about, quite literally, "all that breathes". The humans are just one more animal trying to eke out a living in and

"Black kites now replace vultures as Delhi's chief recycling service, cleaning up after the city's slaughterhouses"

around the streets of Delhi, one of the world's most populous cities.

The cousins compare notes on the threat of nuclear war between India and Pakistan while, barely 2 kilometres away, riots tear up the streets. Feral pigs cross a nearby stream. A millipede eases itself out of a puddle, even as a passing plane casts its reflection in the water.

The documentary opens with a sumptuous panning shot across a rat-infested rubbish dump. Filmed at a rodent's-eye level,



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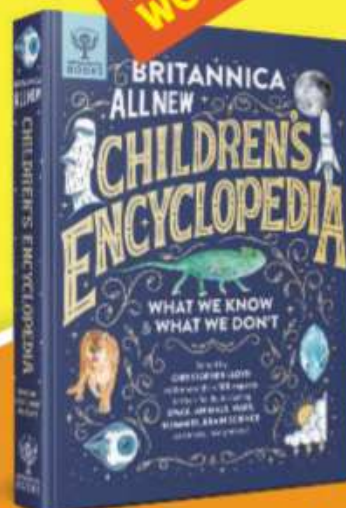
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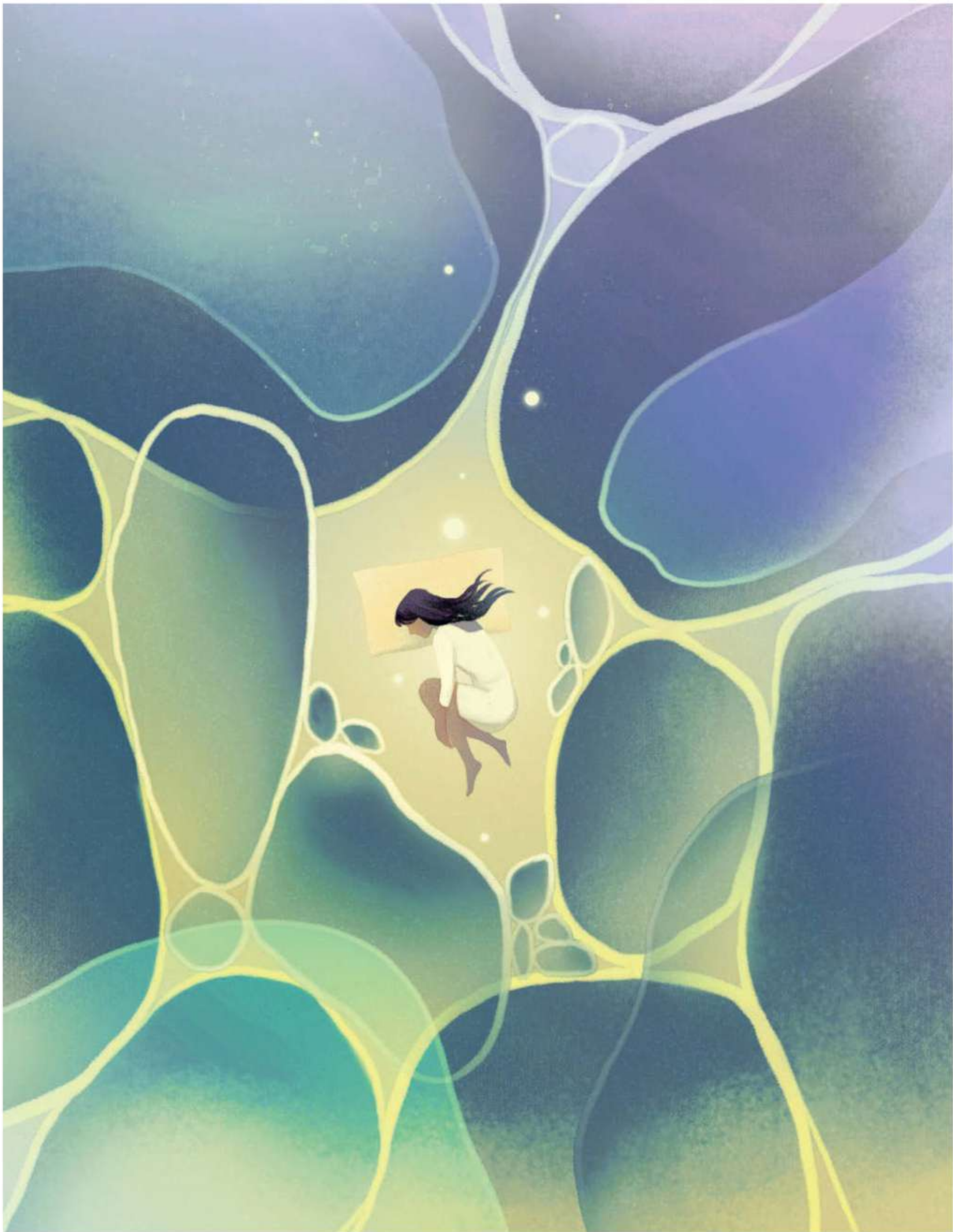
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JASU HU

Rest easier

Insomnia is a nightmarish problem – but at last we know why it occurs and the best ways to tackle it, finds **David Robson**

“**H**ow do people fall asleep? I’m afraid I’ve lost the knack,” muses the unnamed protagonist in Dorothy Parker’s 1933 short story *The Little Hours*. “Early to bed, and you’ll wish you were dead. Bed before eleven, nuts before seven.”

You will almost certainly relate to this frustration if you have ever found it difficult to nod off. The more you try to create the right conditions for sleep, the more elusive it appears; the very desire makes it impossible to achieve. Parker’s character experienced such angst from her unwanted wakefulness that she considered “busting [myself] over the temple with a night-light”.

That may be a familiar feeling for many: insomnia is a common condition. It is also one that has far-reaching health and economic impacts. Yet, for decades, scientists had struggled to offer a good solution. But an explosion in sleep research over the past few years has helped to identify the neurological and mental processes underlying it. This deeper understanding of how the brain can cause this debilitating condition means we have reached a turning point in its treatment. Simply put, we are now in a much better position to work out why someone has trouble sleeping – and the best way to bring them the rest they so desperately seek. “Insomnia is a solvable problem,” says Colin Espie at the University of Oxford.

That will be sweet music to many ears. The chances are that either you, or someone very close to you, could directly benefit from this new knowledge, given how prevalent insomnia is. According to various surveys, a third of people regularly experience difficulties falling and remaining asleep. To be considered insomnia, this nocturnal unrest must occur at least three times a week over a period of more than three months and, crucially, the sleep loss must not be linked to external factors, such as a crying baby or too much partying. It must also be accompanied by

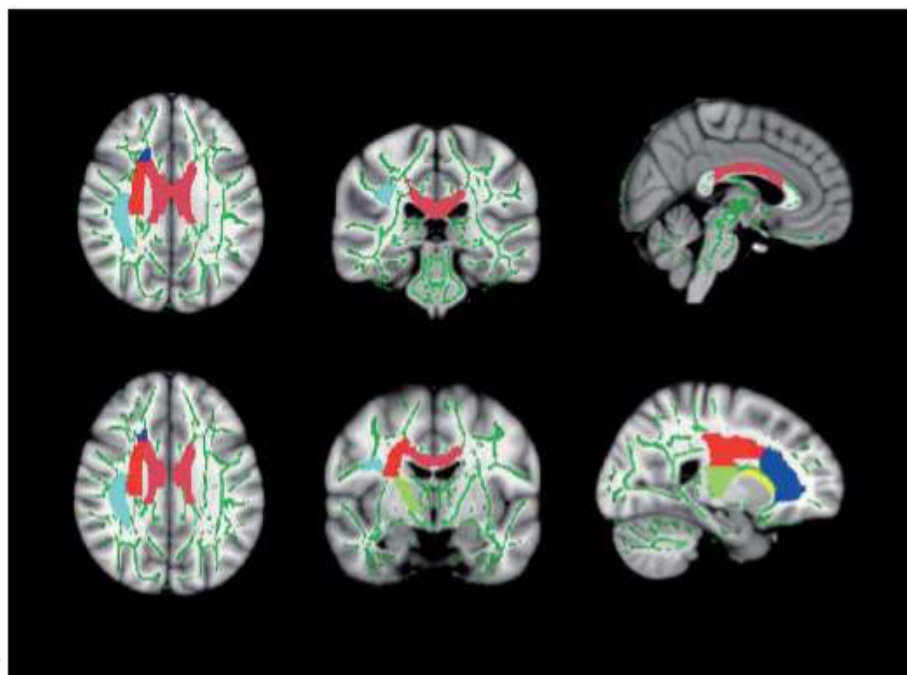
impaired daytime functioning, such as fatigue, irritability or struggles concentrating. Around 10 per cent of the population meet these stringent criteria, though there are significant differences between men and women (see “The gender sleep gap,” page 41).

Insomnia comes with a health burden: those who experience it are at an increased risk of depression, diabetes, cardiovascular disease and Alzheimer’s disease. The condition has financial implications too. In the UK alone, the lost productivity due to insufficient sleep is equivalent to 1.7 million working hours per year, amounting to an economic hit of £42 billion (\$50 billion). In the US, 9.9 million working hours are lost each year – equating to a \$411 billion blow to the economy there. These figures suggest insufficient sleep is costing these countries roughly 2 per cent of their GDP. So what can be done about it?

In an ideal world, we would banish insomnia with universally effective sleeping pills that are free from side effects. Unfortunately, such pills don’t yet exist. Earlier this year, Andrea Cipriani at the University of Oxford and his colleagues examined the published evidence on 30 sleeping pills, with a comprehensive meta-analysis of more than 150 clinical trials. The research team decided that in order for any candidate medication to be considered effective, it should act relatively quickly – within one month – and provide relief for at least three months, while being well tolerated.

The results were disappointing. In total, just two of the 30 medications were shown to provide both short and long-term relief. One of these – eszopiclone – boosts the actions of an amino acid called GABA, which inhibits electrical signalling in neurons. The second – lemborexant – blocks the action of the neuropeptide orexin, which makes neurons extra excitable. Both medications are approved for use in the US, but not yet in the UK.

Significantly, Cipriani’s team found that some of the most commonly prescribed ➤



Some brain regions (highlighted) behave differently in people with insomnia, hinting at a specific kind of dysfunction

"Excessive worrying about sleep loss seems to worsen daytime symptoms of insomnia, including fatigue"

drugs to treat insomnia – including benzodiazepines, which also work through the GABA pathway – appear to offer no long-term relief, while their undesirable side effects include daytime fatigue, dizziness, general mental foggy and the risk of dependency. There are also pills that either modulate levels of the hormone melatonin or mimic its action in the brain, where, in people unaffected by insomnia, it naturally builds up as the day fades into night and then drops by morning. But Cipriani's team found very weak evidence that these pills could provide even significant short-term benefits. "There's no point in prescribing them as a first-line treatment," Cipriani concludes.

If pills aren't necessarily the answer for people with insomnia, neither are overly simplistic behavioural interventions. From the 1970s until fairly recently, the primary option on this front was education on "sleep hygiene". This includes advice on buying a comfortable mattress and good curtains, so that the bedroom is as restful as possible, while avoiding activities such as drinking coffee in the afternoon or watching TV in bed that

might leave someone feeling too alert when they turn out the light. It all sounds like common sense, but it may not be particularly effective. That was the conclusion of a review published last year examining the results of 89 previous studies into treating insomnia. It found that offering education about sleep hygiene as the sole intervention produces barely any improvement in symptoms.

Ruminative brain

There are ways to really make a difference, though. Psychologists now know they must pay much greater attention to the underlying mental processes that lead to insomnia. Since the 1990s, this has been a major research focus, and the efforts are starting to pay dividends.

Much of this research has centred on the idea that people with insomnia experience "hyperarousal", fuelled by ruminative thoughts, that leaves them feeling anxious and physically on edge. This makes it harder to get to sleep at bedtime, and may prevent them from entering a deep slumber, leaving them more likely to wake up during the night.

Multiple lines of evidence now support this idea, including measures of the brain's structure and function. In 2019, for example, Kira Vibe Jespersen at Aarhus University in Denmark and her colleagues showed that people with insomnia tend to have reduced connectivity between the frontal lobe, the part of the brain associated with self-control, and regions such as the insula that are involved in emotional processing. "The consequences of this reduced connectivity could definitely be a greater difficulty regulating emotional states and stress responses," says Jespersen.

This picture of a ruminative brain going into overdrive also chimes with work published last year by Yishul Wei at the Netherlands Institute for Neuroscience in Amsterdam and his colleagues. They found that the brain activity of someone with insomnia is generally more fixed, so less able to vary. This "inertia" might help explain the tendency for those with insomnia to lock into fixed patterns of negative, repetitive thoughts, concluded the researchers.

As you might expect, ruminative thinking may be particularly harmful if the anticipation of sleep itself is the subject of these thoughts, putting someone in a state of high arousal at the very time they need to be relaxing. There is also evidence that people with insomnia show heightened activity in the amygdala – another brain area responsible for processing emotions – if anything reminds them of sleep.

Even more importantly, excessive worrying about sleep loss and its consequences seems to worsen the daytime symptoms of insomnia – which include fatigue and problems concentrating – through a process known as the nocebo effect. Like its more benign twin the placebo effect, the nocebo effect is a type of self-fulfilling prophecy. When it strikes, negative expectations lead to more negative outcomes than would otherwise occur.

Various observational studies offer evidence in line with this idea. The more that people worry about their sleep loss, the worse their symptoms – independent of how well they are actually sleeping. Perhaps most tellingly, researchers can even identify a group of "complaining good sleepers" who don't seem to suffer any objective sleep loss, but who experience all the fatigue and concentration problems of people with insomnia, as a result of their negative expectations. The worst situation, of course, is to experience poor

The gender sleep gap

About 10 per cent of people experience insomnia, but it is women who are particularly hard hit (relatively few studies to-date have explored the prevalence of insomnia among transgender people).

Research published last year by Liang-Nan Zeng at Southwest Medical University in Luzhou, China, and her colleagues pooled the data of 13 studies from various parts of the world covering hundreds of thousands of participants. The meta-analysis revealed that the odds of a woman having insomnia are around 60 per cent greater than the odds of a man having it.

The reasons for this may be both biological and social. Around three-quarters of pregnant women experience insomnia in their third trimester. These symptoms can continue after the birth – caused partly by the huge life changes, but also by fluctuations in progesterone and melatonin, both of which normally regulate sleep. Symptoms of the menopause, such as hot flushes and night sweats, can also create prolonged sleep disturbances.

Psychological research suggests that women are also more predisposed to negative rumination, which may prevent restful sleep.

sleep and excessive worries about the consequences – the “complaining bad sleepers”. People in this category are the most likely to live with the cognitive impairments and the physical signs of insomnia, such as high blood pressure.

The good news is that with this clearer understanding of the causes of insomnia – and of the thoughts that run through the minds of those with the condition – effective psychological therapies are now available.

Sleep strategies

One tried-and-tested solution is cognitive behavioural therapy for insomnia (CBTI). When it is carried out in person, this typically takes place over four to six sessions, during which a therapist will discuss strategies to break free of rumination, when it occurs. Rather than willing themselves to sleep, for example, the person may be told to direct their thoughts to staying awake. This counterintuitive technique, called paradoxical intention, can reduce the person’s sleep “performance anxiety”, leading to more rapid sleep onset. The therapist will also help counteract negative beliefs about sleep loss, if, say, they have started to catastrophise about the effects of even minimal disturbances. For good measure, CBTI also includes education on concepts such as sleep hygiene, which can help when combined with the cognitive strategies. Overall, more than 70 per cent of people show improved sleep after CBTI and 40 per cent go into remission from their insomnia, according to a recent review.

Mindfulness and behaviour therapy for insomnia (MBTI) is another rising star. As the name suggests, it is based around the Buddhist goals of non-judgemental awareness and acceptance, with participants trained to notice the thoughts and feelings they might have around their sleep without necessarily trying to change them. “It’s more how you relate to that thought, rather than just the content itself,” says Jason Ong, a former professor at Northwestern University in Illinois who pioneered the technique and who is now director of behavioural sleep medicine at US company Nox Health.

The passive observation of the thoughts, and the recognition of their fleeting nature, is meant to defuse some of the person’s frustrations and prevent them from being

Sleep hygiene can include relaxing near bedtime – but on its own, it might not help with insomnia



PRESSMASTER/SHUTTERSTOCK

“Rather than willing themselves to sleep, a person may be told to direct their thoughts to staying awake”



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STEVE MCCURRY/MAGNUM PHOTOS

Mindfulness can help some people cope with insomnia

"Over my career, all we've ever been able to give people is pills, so this is a real breakthrough moment"

drawn into the rumination and worry that exacerbate their distress. Clinical trials back this up. A 2018 study showed that MBTI can significantly reduce insomnia symptoms, while a 2020 study showed that these benefits last long after the therapy has finished.

Most insomnia researchers agree that each person's insomnia will differ in the details of its causes and consequences. With time, however, it may be possible to identify the particular flavour of someone's complaint, and to predict which therapies will prove most beneficial.

Tessa Blanken at the University of Amsterdam in the Netherlands has already taken some important steps in this direction. Analysing masses of data on people's experiences of insomnia and its potential causes, she has identified five distinct subtypes of the condition, each with unique patterns of sleep-time arousal and daytime distress.

Earlier this year, Blanken showed that people with some of these subtypes are much more likely to develop depression as a result of their sleep loss, and that their mental health was especially likely to benefit from CBTI. In the

future, she hopes such discoveries might help to personalise treatments. "We could find when particular factors are of importance for particular people and the mechanisms through which the treatment works," says Blanken. "We could then prioritise the people who would gain the most from a particular therapy."

Smartphone saviour

But such ambition is unlikely to be met in the near future, largely because of a lack of available therapists. "There are thousands of patients for each person trained in CBTI," says Daniel Gartenberg at the Pennsylvania State University. This means that the majority of people with insomnia are still given medications, despite the evidence favouring the psychological therapies. "It's perverse that we have a common condition for which the evidence-based treatment is not [widely] available," says Espie.

Such frustrations have led a growing number of sleep scientists, including Espie and Gartenberg, to investigate whether our smartphones might hold the answer, with

sophisticated apps that provide, usually for a small fee, the kind of insight and guidance normally offered by a therapist.

Automated therapy has some obvious limitations over face-to-face encounters. "The human relationship is very important," says Cipriani. But the results of recent trials show that these technological approaches are worth pursuing. Take Espie's app Sleepio, for example. This provides a six-week CBTI course, with an AI algorithm that helps to tailor the app to the patient's behaviour – reported through an online sleep diary or recorded through wearables. In May, the National Institute for Health and Care Excellence, which gives guidance on which treatments doctors should use in England and Wales, recommended that Sleepio should be made freely available on the National Health Service in those countries, based on data from 12 recent trials. Espie says that the remission rate in one study was greater than 70 per cent. "Over my career, all we've ever been able to give people is pills, you know, so this is a real breakthrough moment," he says.

Gartenberg is pursuing a similar course of action in ongoing trials of his app, SleepSpace. Like Sleepio, it tracks data from someone's phone or smartwatch for a personalised form of CBTI. Through a smartphone's speakers, it also delivers short pulses of restful sound at night that are designed to induce the right frequencies of slow brainwaves associated with sleep, and it can be connected to smart light sources that will change the hue to fit the stage of your circadian rhythm. Gartenberg says that SleepSpace could be used together with trained therapists or as a standalone treatment – provided that trial results are positive.

We may not yet have an easy, quick fix for sleepless nights – but most people with insomnia should soon be able to access some good, evidence-based therapies, without resorting to potentially addictive pills. Parker, if she were writing today, could have her sleep-deprived protagonist put aside her lamp. There are now much better solutions than "busting" oneself over the temple with a night-light. ■



David Robson is author of *The Expectation Effect: How your mindset can transform your life*



NABIL NEZZAR

Inside the Neanderthal mind

Our closest cousins died out some 40,000 years ago, but we can get a glimpse of their thoughts from the objects they left behind, archaeologist **Rebecca Wragg Sykes** tells Colin Barras

DID Neanderthals think like us? We used to assume that our closest ancient human relatives, who lived in Europe and Asia for hundreds of thousands of years, were concerned only with survival. But in the past few decades we have discovered various things they made that had no clear practical purpose: a shell coloured with red pigment, a deer bone engraved with chevrons and a ring of stalagmites assembled deep inside a cave.

Archaeologist Rebecca Wragg Sykes, honorary fellow at the University of Liverpool, UK, and author of *Kindred: Neanderthal life, love, death and art*, is fascinated by these artistic – or what she calls aesthetic – objects. She spoke to *New Scientist* about whether they bring us closer to understanding how Neanderthals thought about the world, and what clues they offer to the species' mysterious disappearance. ➤

Colin Barras: How can we get inside the Neanderthal mind?

Rebecca Wragg Sykes: Clearly, there are no Neanderthal texts, so we can't hear descriptions of what they were thinking about the world around them in their own voices. But there is a mass of information in the material they left behind. In a sense, what we can do with those artefacts is limited only by our imagination.

How we can glean information from these artefacts?

One way to is to study their technology through a technique called refitting – basically, putting things back together, looking at the sequences they used for knapping, the process of flaking stone blocks to make tools. It's "slow archaeology": you excavate meticulously and collect even the tiniest objects. Then you try, piece by piece, to fit those fragments back together. It takes hundreds of hours, but if you don't do that you're missing so much about how things were made and used.

This is as close as we can get to time travel because you recreate this series of moments and you can watch the decision-making that was going on. For instance, a Neanderthal might encounter a natural flaw – say, a crack – in the cobble they're flaking, and you can watch how they decide to problem solve. It's almost like looking over their shoulder.

**NewScientistLive**

Rebecca Wragg Sykes will be speaking about the minds of Neanderthals at New Scientist Live on 9 October.
Join us at the world's greatest festival of science at ExCeL London from 7 to 9 October and online [newscientistlive.com](https://www.newscientistlive.com)



That's mind-blowing. What do you think is the most exciting recent discovery that gives new insight into Neanderthal cognition?

Archaeology advances not just by single new discoveries, but by the knowledge and inferences that emerge through comparing many sites, many analyses. So I'll be cheeky and choose a category: our understanding of Neanderthal organic technologies.

We have known for quite some time that Neanderthals invented the first synthetic substance, birch tar, at least one use for which is as a glue in tool-making. But in recent years there has been renewed interest in assessing the techniques of manufacture and the cognitive complexity involved in the process.

Wooden objects are immensely exciting too, because they are so rare. New discoveries of probable digging sticks are very interesting, such as ones found in central Italy that are nearly 200,000 years old. These are extremely

important tools for hunter-gatherers, and show the same clear appreciation of material properties and clever production methods as used for making spears. They used fire to soften harder wood.

Is a similar approach useful for studying objects that may have had social or symbolic purposes? For instance, a 2018 study concluded the notches on an animal bone might have been made by a Neanderthal to tally or keep count.

When archaeologists find objects beyond the "everyday", which may be to do with aesthetics or point to complex mental processes, it's exciting. But we are also really cautious. No one wants to make claims that are later dismantled. Very carefully argued cases were made in 2018 for the Les Pradelles object you mention – a hyena bone from a site in France marked with tally-like notches – as representing something extraordinary. The same peer scrutiny was applied to the 2021 discovery of chevrons carved on a giant deer bone from Einhornhöhle in Germany at least 51,000 years ago.

At every stage we second-guess ourselves and look for different possibilities. If, after all of that filtering, you're still left with an object that doesn't have a clear explanation from a functional or survival perspective, then you know it's reliably "weird". It's an object that tells us something deeper about how Neanderthal minds worked and how they engaged with the world.

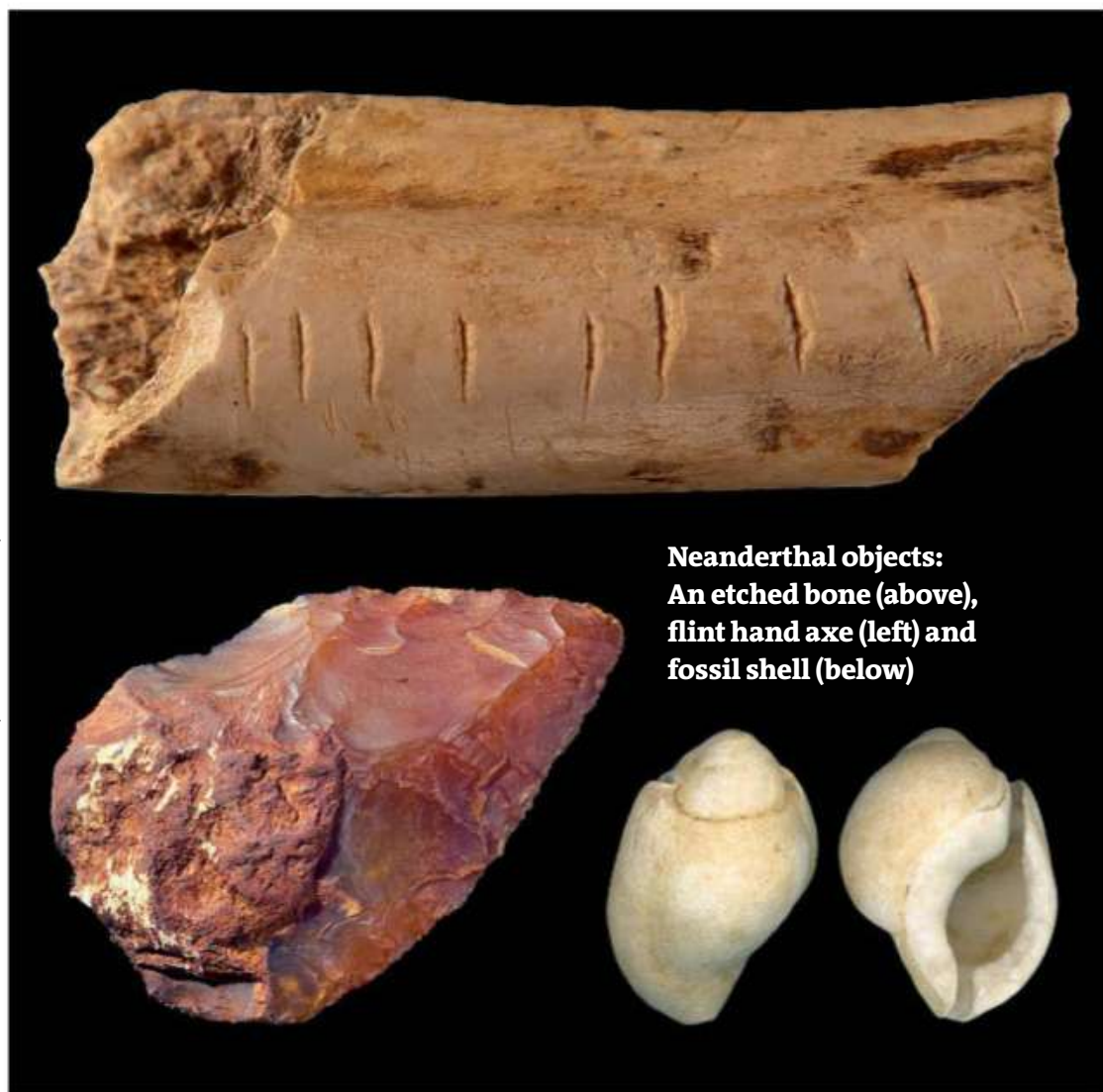
What is your favourite "reliably weird" object?

A shell from Grotta Fumane in Italy, which was left there more than 47,000 years ago. It's actually a small fossil originally picked up at least 100 kilometres away. At some point, a Neanderthal had rubbed the outside of the shell with red mineral pigment that had been sourced elsewhere. There is no clear simple explanation for this object: it's not food waste and doesn't have an obvious functional use.

As hunter-gatherers with no means of transport except walking, Neanderthals wouldn't have carried anything without value. I can imagine the shell itself being noticed out of curiosity, and the pigment does seem to make most sense as a means to alter the surface appearance for a visual aesthetic effect.

A circle constructed from stalagmites by Neanderthals more than 174,000 years ago





Neanderthal objects:
An etched bone (above),
flint hand axe (left) and
fossil shell (below)

"It's almost like looking over the shoulder of a Neanderthal"

Why might someone have decorated this object?

We will never know what it was understood as, how many individuals were involved with it or how long it had been held onto for. But this object opens many windows to thinking about Neanderthals as motivated by more than mere survival. I think we must consider them as beings curious about materials, and interested in the aesthetics of engaging with them, for instance applying colour to a surface.

I think the idea of who these objects are being made for is fascinating. We tend to assume such artefacts are designed for an audience, but perhaps this is not the case.

So, when we struggle to understand the significance of an aesthetic object, maybe we're not alone? Perhaps an object that was meaningful for one Neanderthal might have puzzled another?

That's a really interesting question. What would a different Neanderthal group make of a site like, say, Bruniquel [a French cave made famous in 2016 when it was discovered that, more than 174,000 years ago, Neanderthals had snapped hundreds of stalagmites off the cave floor and arranged them into rings several metres across]? I think they would have been intrigued. They would have recognised purposeful activity, but it

might not have had the same resonance for them as for the original creators.

Why do you think this?

When we look at Neanderthal stone tool technology, some core flaking methods were apparently commonly known and understood, albeit with some regional differences. But it's not as easy to see that universality with their rare aesthetic objects.

Is this different to the aesthetic objects made by early *Homo sapiens*?

I feel like Neanderthal aesthetic objects are a more intimate form of expression, and there was never the intention to use them as badges of identity, woven into encounters with other groups. Early *Homo sapiens* had a greater repetition and coherence in their material culture than we see with Neanderthals. Instead of one red-coloured shell, we find many in a single site occupied by *H. sapiens*.

Could that imply that interacting with other groups wasn't as important or as routine for Neanderthals?

Neanderthals were living in more isolated groups than most early *H. sapiens* were, and while encounters would have been important socially, they may have been rare enough that

material culture was not systematically integrated into those interactions.

Do these findings bring us any closer to solving the mystery of the Neanderthal extinction?

This question is so hard to answer. It's clear that Neanderthals were good at being hunter-gatherers, and they survived all sorts of dramatic climate change. To some extent they were able to flexibly adapt. But, yes, there are these differences with *H. sapiens* that have been highlighted more and more as we have developed a better understanding of the archaeology and the genetics.

So far, every early *H. sapiens* genome we have looks like it comes from a well-connected population, unlike a lot of the Neanderthal genomes. Maybe the ability to network and cooperate did make a difference.

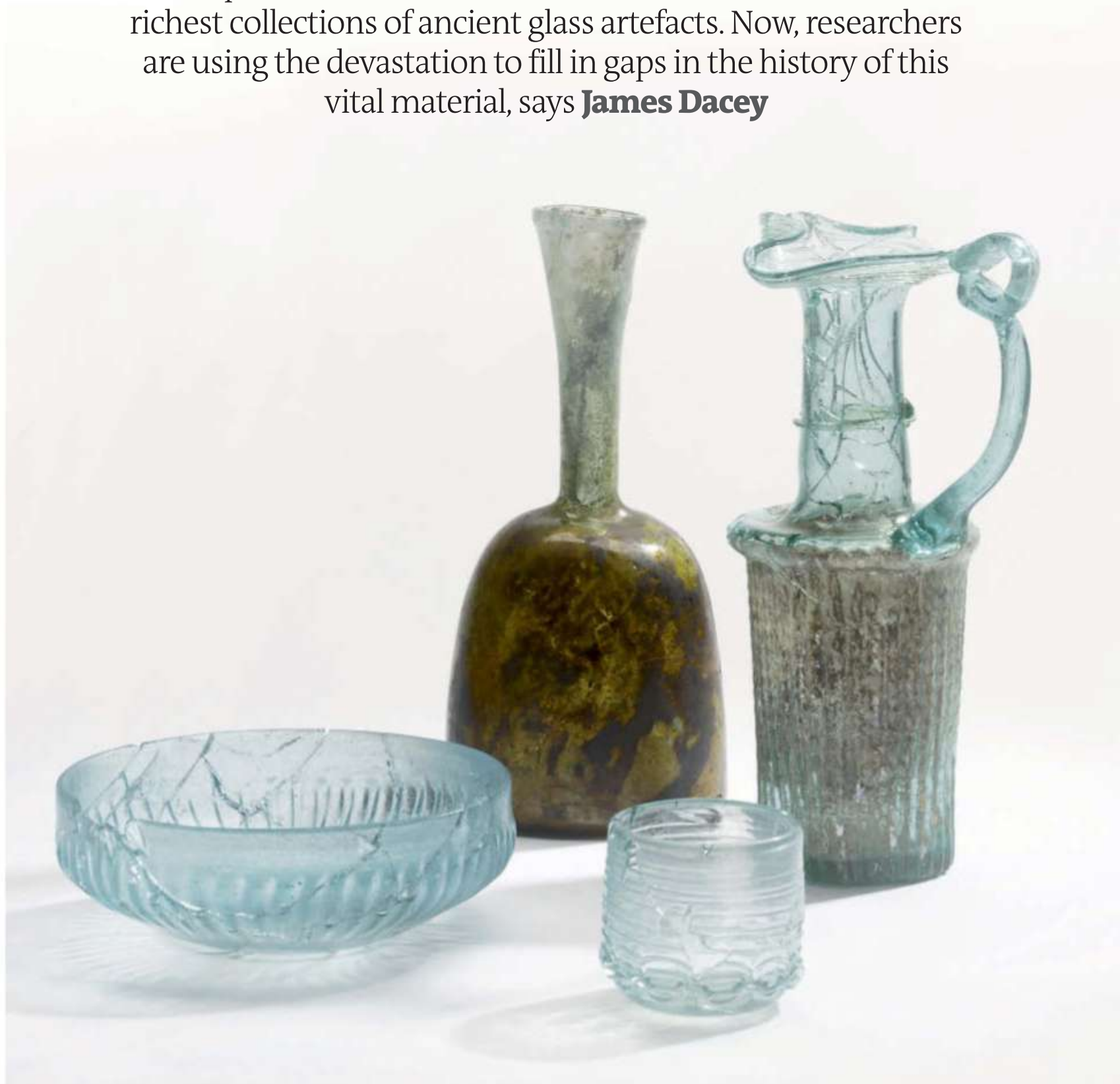
I find it hard to accept the argument that Neanderthals were heading for extinction anyway. I think we would very much like there to be a reason for our survival that makes us sound great. But maybe we were just lucky. ■



Colin Barras is a features editor at *New Scientist*

Piecing together a shattered history

In 2020, an explosion in Beirut caused 218 deaths and widespread destruction. It also shattered one of the world's richest collections of ancient glass artefacts. Now, researchers are using the devastation to fill in gaps in the history of this vital material, says **James Dacey**



THE ARCHAEOLOGICAL MUSEUM, AMERICAN UNIVERSITY OF BEIRUT



New Scientist video

To see our video on the shattered glass of Beirut, go to youtube.com/newscientist

PICTURE a 2000-year-old glass jug – turquoise tint, elegant spout. It probably decanted wine at lavish Roman banquets, surviving earthquakes and war before finding itself standing among similarly beautiful, delicate pieces in the American University of Beirut (AUB) Archaeological Museum in Lebanon. Then, in an instant, it shatters.

At least 218 people died and thousands more were injured when a giant pile of ammonium nitrate exploded at the port of Beirut on 4 August 2020. The blast was one of the largest non-nuclear, human-made explosions recorded, and the subsequent shock wave wreaked devastation for kilometres around.

The incident was also a cultural calamity. The wider region around Lebanon is touted as the crucible of glass production, a material that has helped shape civilisation. As one of the oldest museums in the area, the AUB housed a particularly rich collection of ancient glass artefacts. The blast smashed 72 jars, bowls, cups and other vessels dating back to the ancient Romans (1st century BC to 5th century AD), the Byzantine Empire (4th to 15th century AD) and the Islamic Golden Age (8th to 13th century AD).

Rather than try to fix everything, however, AUB Archaeological Museum curator Nadine Panayot saw an opportunity in the debris. Much about the origins of glass production is opaque and yet modern material analysis techniques could offer clarity, if only they could be brought to bear on such precious collections. The shattered fragments of material presented an ideal way to do this. Now, Panayot is collaborating with physicists and engineers from around the world in the hope of opening a new window on the world of ancient glass.

Glass is typically made of silicon dioxide (silica), with small quantities of other chemicals that help fashion the final material. It is defined by the jumbled, or amorphous, arrangement of its molecules, distinct from the ordered structure of crystalline materials. Profoundly versatile, glass has become a vital material in the modern world, from the windows that let light into buildings and the spectacles that correct vision to the camera lenses that capture images and the optics in microscopes and telescopes that reveal nature at its smallest and grandest.

It can be formed into optical fibres and used to deliver the internet across the globe, and it is a component of renewable energy technologies – solar power in particular. In fact, the United Nations has declared 2022 the International Year of Glass to celebrate its importance.

Yet glass wasn't always so ubiquitous. Early humans used obsidian, or volcanic glass, and other natural forms for tools, but it wasn't until the late Bronze Age that our ancestors began to manufacture glass objects. Archaeologists have found evidence of this early glassware in tombs and temples dating from around 1600 BC onwards, located across what was then ancient Mesopotamia – the region that today incorporates Iraq, Kuwait and parts of Iran, Syria and Turkey (see map). Clues identified in the chemistry of preserved glassware seem to confirm the origins of glass production in Mesopotamia, with ancient Egypt manufacturing its own raw glass within the next 100 years. Pharaohs treasured it alongside gemstones like lapis lazuli, turquoise and amethyst. Clay tablets known as the Amarna letters from the 14th century BC reveal orders from Egyptian leaders for additional glass from the Levant – the eastern Mediterranean, which includes present-day Lebanon, Syria, Israel and Palestine – to meet soaring demand.

The basic recipe for glass was the same then as it is now: you take some silica, often just a pile of sand, then heat until molten in the presence of salts and other “fluxes” that lower its melting temperature. Additives can then add colour and alter the material's physical properties.

Yet much of the history of glass remains a mystery. Precisely how and, in particular, where glass was made and processed in ancient times are questions that have been hard to address, owing to the lack of archaeological evidence from ancient glass-manufacturing sites. Finding more examples of these would be a breakthrough.

A further complication is pinpointing the provenance of glass. An item's form and style can give you a decent idea of where it was created, be it a jug, drinking vessel or item of jewellery. But these were rarely produced in the same place as the ingots of raw material. “Chunks of glass, the size of a head, were ➤



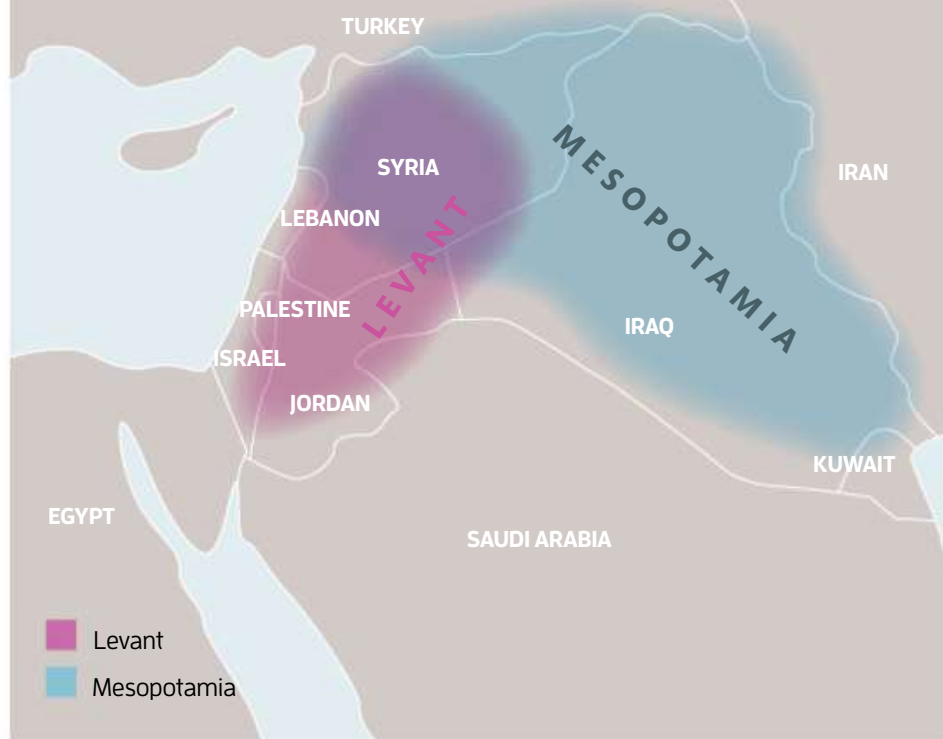
Main image (page 46, left to right): Early to mid Roman-period glass bowl; bell-shaped flask from Islamic Golden Age; late Roman-period small cup; high-necked jug with turquoise tint from early Roman period
Below: A pile of ammonium nitrate exploded in Beirut, Lebanon, on 4 August 2020. The blast killed 218 people and injured thousands



BOTTOM R: ANWAR AMRO/AFPI/GETTY IMAGES; TOP R: THE ARCHAEOLOGICAL MUSEUM, AUB

The crucible of ancient glass production

Glass production workshops dating back to the early days of the emerging industry are thought to have been situated in Mesopotamia, which incorporates Iraq, Kuwait and parts of Iran, Syria and Turkey, and the ancient Levant, which borders the Mediterranean Sea to the east



shipped across the Roman Empire,” says Thilo Rehren, an archaeological materials expert at the Cyprus Institute. “You find them up in York [UK], Madrid [Spain], Lyon [France] and Bulgaria. Local workshops were remelting the glass and blowing it into the local preferred shape and style of an object.” As a result, the origin of a glass object isn’t necessarily the same as the origin of the material it is made of.

Since the basic building blocks of ancient glass varied little across wide areas, to answer the where and when of its origins, you need to search for subtle differences in the material’s trace elements. Only advanced chemical analyses can identify how the basic mix varies, which gives clues to the material’s provenance.

Researchers have already identified the type of sand or crushed quartz pebbles used in some ancient glassware, and from that the regions where production of the glass probably took place. Rehren says that 99 per cent of the glass ingots used in the Roman, Byzantine and early Islamic periods were produced along the eastern Mediterranean coast, in a stretch from the Nile delta up to present-day Lebanon. But there is a knowledge gap around Lebanon, largely because war and political instability have hindered academic organisations and archaeological investigations in the region. For example, although we know of glass production sites in ancient Egypt, no one has ever found evidence of workshops producing raw glass ingots in the Levant or Mesopotamia.

“In those first few weeks after the explosion, we treated the museum floor as a crime scene”

Volunteers helping efforts to rescue the shattered glassware



Rising from the ashes

All of which explains why the shattered glass collection offers a unique opportunity.

Technological advances in compositional analysis could help pinpoint where the raw materials for a piece of ancient glassware were taken from and, as such, promising locations to look for archaeological remains of ancient glass production sites.

For a combination of reasons, including recent economic and political volatility, the academic projects to exploit these advances haven’t been available in Lebanon. But in the aftermath of the blast, museum curators reached out to international contacts, who brought in partners and the latest technological know-how to begin the recovery work. What’s more, the breakages themselves were an advantage because freshly exposed shard edges provide scientists with surfaces that are more representative of the original composition. In this way, the blast brought Panayot and her colleagues the chance to properly probe the chemical composition of scores of pieces of ancient glassware for the first time.

Initially, the response to the blast had been simply to salvage as much as possible. “In those first few weeks after the explosion, we treated the museum floor as a crime scene,” says Panayot. Along with a team of volunteers, she and Claire Cuyaubère, a conservator from the French Institute of National Heritage, sifted through thousands of shards, distinguishing ancient glass from that of the broken showcases. The team managed to piece together 10 glass objects and another six were repaired earlier this year in a workshop led by Stephen Koob, chief conservator emeritus at the Corning Museum of Glass in New York. Panayot has insisted that restoration work doesn’t try to reconstruct gaps in the glass items, so that instead they “carry their scars – just like the human bodies that have been scarred by this explosion”. A further eight of the more robust glass items were sent for repair at the British Museum, London, where they are on display at an exhibition called Shattered Glass of Beirut until 23 October.

But Panayot recognised the opportunity the shattered glass presented. Most of the glassware damaged in the explosion was created during the first millennia AD many centuries after glass was first manufactured in Egypt and Mesopotamia. Nevertheless, tracking the movement of the material and finished pieces could give insights into the dynamic power structures at the time, particularly following the Arab invasions of the 7th and 8th centuries and subsequent political and economic fragmentation. It



Shattered glassware before (below) and after (above) the repair work following the 2020 Beirut explosion. Left: glass flask dating back to the late Roman period, roughly 4th to 5th century AD. Right, a glass beaker dating back to the early Roman period, roughly 1st century AD

could even point towards new archaeological sites that might give greater clarity to the early years of glass production.

Very few of the museum's glass artefacts have a documented place of origin or official age, and for many items, curators only have a rough idea of their provenance from studying the form and style. Take that elegant, turquoise tinted jug, for instance (see main image, overleaf). Curators think it dates to the first or second century AD, but now they can attempt to corroborate such inferences. Analysis of other regional glass from the period has identified the mineral natron mined from dry lake beds in Egypt as a flux, and it is likely that most objects from the AUB were also produced with this flux. However, the kind of analysis Panayot has unleashed could reveal the source of the silica, the additives and fuel used and ultimately where the raw glass for these pieces was produced and transported. As well as identifying bulk materials, traces of decoration (such as engraving or paint) could shed light on the artisanal techniques and tastes of the time, while residues within a vessel might indicate its use.

The Lebanese Atomic Energy Commission has now provided the museum with a handheld X-ray fluorescence analyser. It looks like a cross between a hairdryer and a barcode scanner, but emits X-rays that stimulate elements within a material to give off light at specific frequencies, depending on the substances present. In this

way, it can reveal the material's composition, even including elements that account for just a fraction of a per cent by weight. The AUB team has already used it to collect some data from the glass shards. While fresh shard edges are an advantage, it is a non-invasive technique, and next the researchers plan to scan the more than 1200 pieces that survived the blast intact as well.

Elemental deduction

Malek Tabbal, the AUB physicist who is leading the analysis project, is also in close contact with vitreous materials scientist Andrew Meek and colour scientist Joanne Dyer at the British Museum in London. They have been analysing fragments of the eight glass objects sent there for repair and took some to colleagues at University College London to probe with a specialised form of mass spectrometry. They burned tiny pits invisible to the naked eye in the glass with a laser beam, releasing fine particles of evaporated material. The electrically neutral atoms and molecules of this evaporated material are then charged, so that comparisons of their mass versus their charge can be used to reveal even trace elements in glass down to parts per billion. Twenty years ago, researchers could only identify the 10 to 12 most abundant components; with this technique, they can now typically spot 50 to 55, which means they can pin down the location of the sand used in

the glass far more accurately.

Meek says comparison of provisional findings from the eight objects with large collections of well-provenanced material may reveal previously unknown ancient glass-producing sites. "It may be that a couple of pieces not quite so easy to fit into currently established groups could be found to have been produced in Lebanon," says Meek.

Pinpointing workshops in the ancient Near East where the very first glass production occurred remains a key goal in glass archaeology. Even if the current analysis doesn't lead there directly, the Beirut blast project can build the local science capacity to enable such breakthroughs in the future.

Much of Lebanon is yet to be excavated, leaving scope for big archaeological discoveries in the future. For her part, Panayot has been investigating the archaeological site of Anfeh in northern Lebanon, an important economic centre from the late Bronze Age to the Ottoman period. With such a rich cultural history, Lebanon can emerge as an important player in heritage studies in the coming years. It is just a pity it took a tragedy for that to happen. ■



James Dacey is a freelance journalist based in Madrid

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The science of cooking

Getting corny

A great corn on the cob must tread the line between under- and overcooked. **Sam Wong** explains why – and how to do it



Sam Wong is assistant news editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

4 corn cobs

1 lime

2 tbsp unsalted butter

2 tbsp white miso

FRESH sweetcorn is one of the delights of late summer and early autumn. Its sweetness derives from a genetic variant that emerged some time after corn was first domesticated by people in Central America, about 9000 years ago. This mutation, called *su1*, stops the plant turning sugar into starch while it grows. Some sugar is instead converted into a different carbohydrate, phytyloglycogen, which gives sweetcorn its creamy texture.

After harvesting, enzymes begin converting the sugar into starch, so sweetcorn is best eaten on the day it is picked. Some older varieties of corn can lose as much as half of their sugar in 24 hours.

Most sweetcorn sold today comes from super-sweet varieties first developed in the 1960s. These have a mutation called *sh2*, which gives them higher initial sugar levels, and they remain sweet for longer after harvest. They also contain less phytyloglycogen than old-fashioned corn, so aren't as creamy, but newer varieties are beginning to address this.

When you peel back the leafy outer covering, called the husk, you will find a fibrous material known as corn silk. A strand is attached to every kernel, and each one is a tube that pollen travels down to reach the corn's ovaries, which develop into the kernels.

The silk can be a pain to remove. One way to make the process easier is to leave the husk on and cook the corn in a microwave for 3 to 4 minutes. Then, wearing gloves, cut off the stalk end of



NEW AFRICA/SHUTTERSTOCK

the ear just after the final row of kernels, grab the end – where the silk strands come together – and shake the corn ear out of the husk.

There are many ways to cook corn on the cob. I love grilling corn on the barbecue until the kernels start to blacken. This creates some wonderful roasted flavours thanks to the Maillard reaction, but the downsides are that the kernels are less juicy and the wrinkled skins stick in your teeth.

When corn is overcooked, pectin, a carbohydrate that forms the glue between plant cells, dissolves. This results in a mushy texture. For perfectly cooked corn, Lan Lam at *America's Test Kitchen* advises bringing a large pot of water to the boil, dropping the corn cobs in, then turning off the heat and leaving the pot covered

for between 10 and 30 minutes. The temperature will quickly drop below 85°C (185°F), the point at which pectin dissolves, but should remain above 65°C (149°F) – high enough to gelatinise the starch inside the kernels.

The kernel skin, the pericarp, isn't very permeable, so don't bother salting the water. Instead, add salt directly to the cooked corn. My favourite way to serve corn on the cob, taken from Meera Sodha's book *East*, is with miso butter and a squeeze of lime. Use a fork to mix the miso paste into soft, unsalted butter – the miso is salty enough on its own – and slather it onto the cooked corn. ■

The science of cooking appears every four weeks

Next week

Stargazing at home

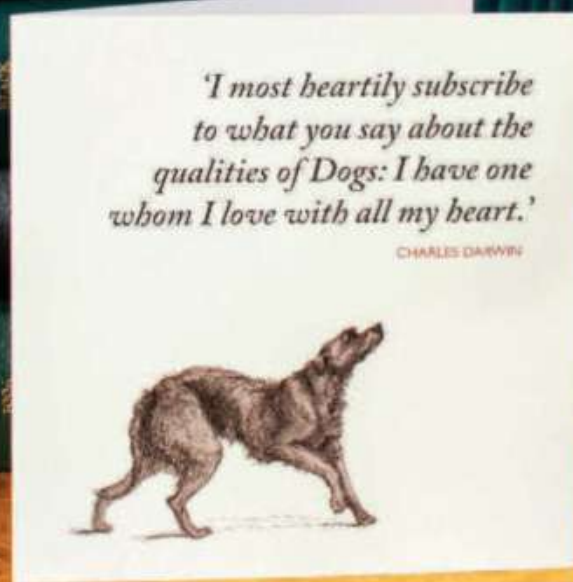
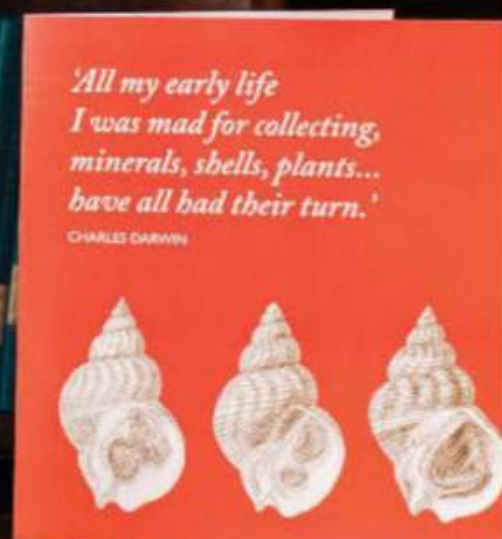
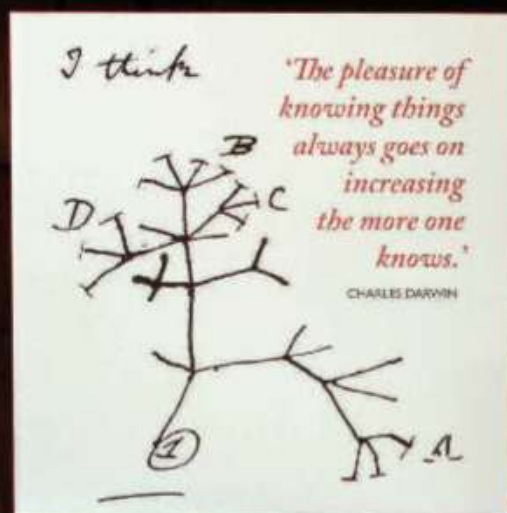
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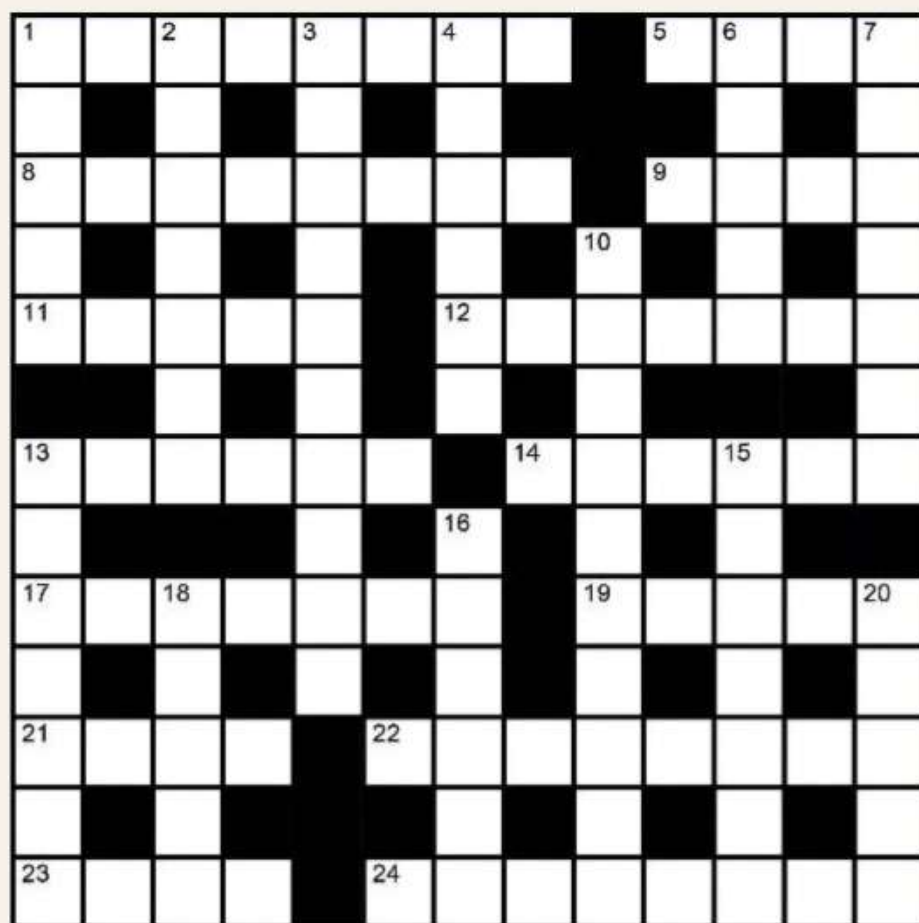
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Cryptic crossword #93 Set by Wingding



Scribble zone

Answers and the next quick crossword next week

ACROSS

- 1** Bit dissolved and faded (8)
- 5** Heard farm animal's cry (4)
- 8** Suitable data queue encrypted, concealing uranium (8)
- 9** Vital chemicals include hydrated magnesium silicate (4)
- 11** Discover guanine with gallery backing (3,2)
- 12** Citrus fruit a kind person put in outskirts of Tokyo (7)
- 13** Jack goes into shallow parts of rivers and inlets (6)
- 14** Take in potion of healing, good to go (6)
- 17** Spice wagon not here (7)
- 19** Propelled boat over a rapid eddy dangerously at first (5)
- 21** Source of metal, a large amount reportedly (4)
- 22** Monkey and squirrel eating selenium (8)
- 23** Pull Kelvin – no, to the left! (4)
- 24** Nude dancing welcomed by desirable swinger (8)

DOWN

- 1** Crystallography pioneer and supporter on horse (5)
- 2** Choose half of rock or dance music (7)
- 3** Calamity ultimately interrupting crucial phase of rocket launch somewhere in Northern Ireland (6,4)
- 4** Test a team that secures property (6)
- 6** Legislative body expelling leader's relative (5)
- 7** Nutrient in a closet unexpectedly (7)
- 10** Lacking knowledge, like police officers surrounding narco boss (10)
- 13** Charlie entering broken part of university (7)
- 15** Loos are circulating mist (7)
- 16** A lemur? Yes, sailors say (3-3)
- 18** Gas escaped outside party (5)
- 20** Piece of information originally discovered at University of Miami (5)



Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #171

- 1** What name is given to the process in which Earth's crust folds and makes continental mountains?
- 2** In what year did William Herschel discover Uranus?
- 3** One of the oldest trees in the world, known as Methuselah, is a member of which genus?
- 4** Chains of relatively few amino acids are known as what?
- 5** Which country lends its name to a disease that is currently devastating supplies of Cavendish bananas?

Answers on page 55

Puzzle

set by Howard Williams
#187 Key decision

It is a big day for Mr Hopeful. He has got through to the last stage of a television game show, with the chance of winning a car. If he chooses the correct casket from the four on offer, he will find the keys inside and be driving home in a brand new, top-of-the-range electric vehicle.

He is confident, as he knows that each of the caskets has a clue.

1

The keys are in caskets 2 or 4

2

The keys are in caskets 1 or 3

3

The keys are not in here

4

The keys are here

However, his self-assurance is shattered when the game show host explains that three of the four clues are false.

Can you help Mr Hopeful decide which casket to choose to win the car?

Solution next week

Bow extras

Why, when I see a rainbow, do I perceive two extra colours (yellowish and greenish) directly beneath violet? Am I seeing UV wavelengths, with my brain interpreting them as those colours?

Guy Cox

Sydney, Australia

Your correspondent isn't seeing in the ultraviolet range. Instead, they are seeing a supernumerary rainbow. This is caused by diffraction and interference after the initial refraction of sunlight by raindrops, and tends to happen when the drops are very small.

It is very difficult to photograph (believe me, I have tried).

Nick Canning

Coleraine, County Londonderry, UK

Rainbows sometimes show extra coloured bands directly below the violet band at the bottom.

Human eyes can't detect the UV bow that exists below the violet band. However, the bands that your correspondent saw are

“One of my eyes perceives ultraviolet light very brightly, which means I squint at the UV emitted by fly-killing devices”

visible light and are called supernumerary bows.

Their intensity and spacing vary with the size of the raindrops in the shower that creates the bow. Smaller drops give larger spacing of the colour bands, whereas more uniform drops give greater intensity of colours. These are the result of interference effects caused by the wave nature of light.

Here in Ireland, in summer, we get heavy afternoon showers and often see intense primary bows with strong supernumeraries.

The light from rainbows is polarised, so photographing them through a polarising filter greatly increases the contrast with the background sky.



BY SIGI KOLBE/GETTY IMAGES

This week's new questions

Animal ace What has been the most successful animal ever?

Derek Johnson, *Moreton-in-Marsh, Gloucestershire, UK*

Paddle hand My water aerobics instructor says to press my fingers together to increase resistance. The total surface area is the same with fingers open or closed, so why does it make a difference? **Mary Jo McMullen**, *Tuscon, Arizona, US*

Richard Swifte

Darmstadt, Germany

The extra colours are genuine. They appear because a rainbow in the sky isn't a pure spectrum like that, for example, from a prism.

A prism has smooth, flat sides and is used with a point source of white light to produce the resulting dispersion of colours (equal to individual wavelengths), with each colour emitted in a specific direction. The water droplets that produce a rainbow have rounded sides, so light enters and leaves at various angles to the surface. Also, the sun isn't a point source of light, but has an angular size of half a degree.

These factors lead to each dispersed colour being emitted over a wide range of directions, with consequent overlapping.

This smearing isn't uniform, however: a particular colour is concentrated in a narrow band and is much weaker outside, and it is these bright bands that we see as the main rainbow arc.

They give a reasonable approximation to a pure spectrum, since the weak overlapping contributions from other colours aren't obvious.

Below the main arc, there is a large, brightish, whitish area of all the less concentrated smeared colours, which, due to interference effects, contains faint bands of distinct colours. The least faint are those nearest to the main rainbow arc.

In good viewing conditions, a person with good eyesight could perceive some of these extra colours.

Cats may act superior, but which animal is really the most successful?

Pat French

Longdon Upon Tern, Shropshire, UK

We each perceive slightly different wavelengths of light at each end of the "normal" visible spectrum, perhaps due to natural variations in the eye's cornea or lens.

How we interpret wavelengths of light is cultural too. People who live in the Amazon rainforest perceive finer gradations of green than city dwellers, as demonstrated by physicist Helen Czerski in her TV series *Colour*.

Also, some of us can perceive UV light. I have had the lens in my right eye replaced with an artificial one. My right eye, but not my left, now perceives the longer UV wavelengths very brightly, which means I squint at the UV emitted by devices that kill flies.

Eyelash expression

Why do we open our mouths when we put on mascara?

Mike Tobias

Herne Bay, Kent, UK

I have no idea, but I open my mouth when I put in eye drops.

@Nikicinder

via Twitter

Maybe this is an automatic connection related to surprise, and raising your eyebrows and opening your mouth lifts your eyelids to give better access to your lashes?

@DilysCluer

via Twitter

Because we are trying to look up? My husband opens his mouth when he looks upwards.

@Pete_Branscombe

via Twitter

Opening your mouth is a good way of steadying all of your face muscles for a delicate task. Alternatively, your mouth may just be mirroring what your eyes are doing.

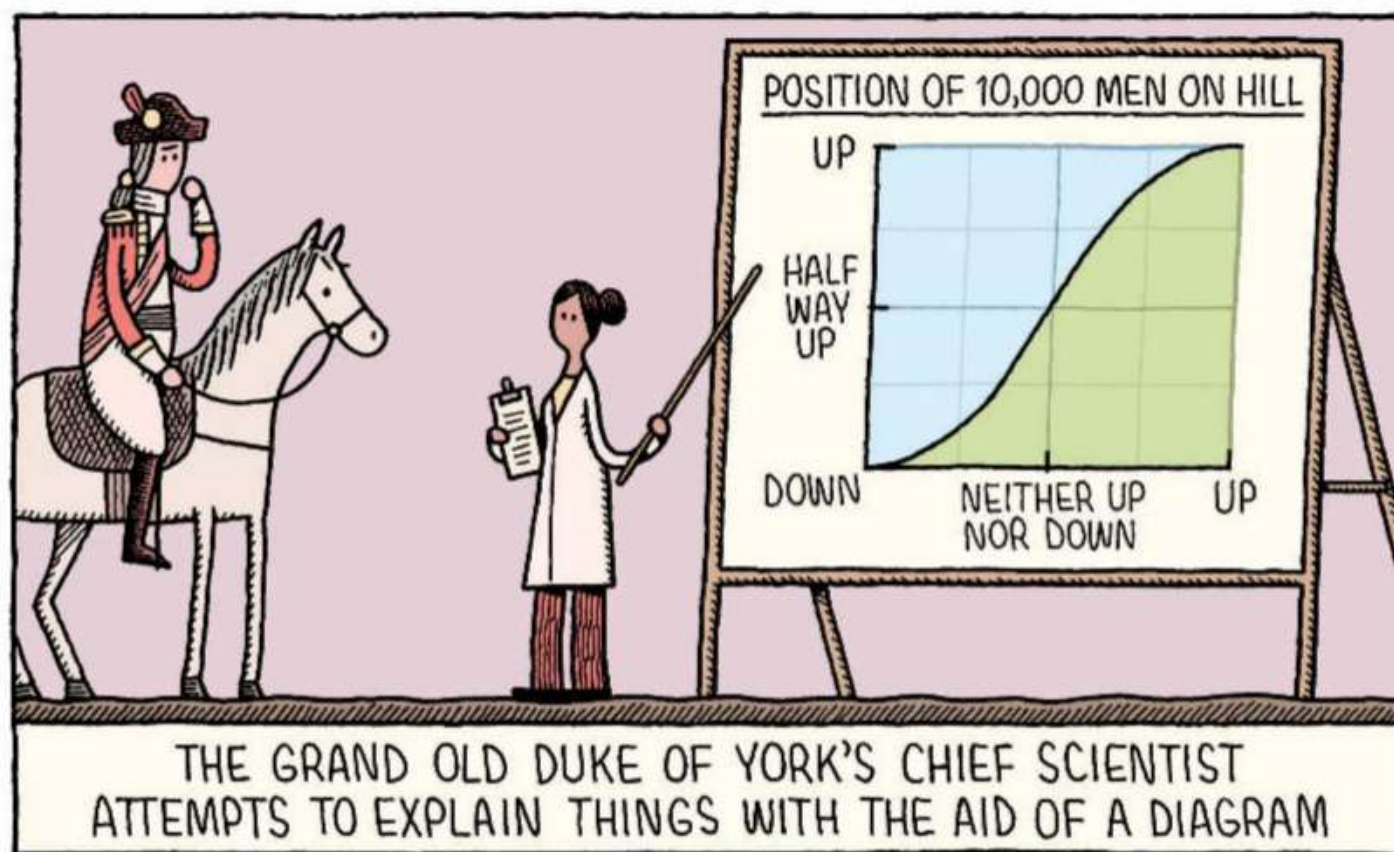


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Gillian Forrester

University of Sussex, UK

You might think there is a simple answer to this question – by opening the mouth, we stretch the facial skin, creating a taut surface around the eyes to facilitate the application of mascara.

However, it seems that these unconscious, synergistic eye and mouth movements are more than skin deep! In fact, the mouth and eyes open together during most exaggerated attempts to open the eyes. It is likely that this pairing is down to how we are wired. Although separate nerves support the movement of the eyelids and mouth, they originate in close proximity to each other in the brainstem, so, when one is activated, it may activate the other.

In addition, human behaviours don't often occur as single body actions in isolation. Instead, we tend to function via the synchronous pairing of two or more motor movements. Take the facial expressions of fear and surprise, both characterised by wide-open eyes and mouths.

“Why do we open our mouths when we put on mascara? The answer isn't as straightforward as you might think”

We share this fear face with our primate relatives, suggesting that these eye-mouth co-activations rely on evolutionarily ancient neural wiring. Studies dating back to at least 1907 document people whose symptoms demonstrate the tight ties between the muscles of the eyes and the mouth. For instance, surgeons noted that children with photophobia (eye discomfort from bright light) would often open their mouths while straining to open their eyes.

Or take cranial synkinesis, a congenital condition where a voluntary muscle movement causes a synchronous involuntary contraction of an independently innervated muscle. Mouth and eye muscles are most commonly affected. Marcus Gunn syndrome, also known as jaw-winking

syndrome, is the most common form of synkinesis, where the individual presents with a drooping eyelid – however, the eyelid will lift or open when the jaw is moved.

To date, the neuroanatomical underpinnings of synkinesis haven't been fully determined. While older research postulates that it results from a damaged nerve, at least one newer study suggests that synchronous mouth and eye opening is a normal characteristic in a significant minority of the general population and results from naturally occurring links between the nerves responsible for chewing and raising the upper eyelids.

While the pairing of the muscle actions may be unconscious, once we tune into them, we can control them. As children, many of us stuck our tongues out when making fine-precision hand actions. However, as adults, we probably modify these behaviours – or at least when in polite company! ■

Answers

Quick quiz #171 Answers

- 1 Orogeny, or orogenesis
- 2 1781
- 3 *Pinus* – it is a Great basin
bristlecone pine (*Pinus longaeva*)
and is 4854 years old
- 4 Oligopeptides
- 5 Panama

Quick crossword #117 Answers

ACROSS 9 Epizoon, 10 Umpteen,
11 Iridium, 12 Arcsine,
13 Isinglass, 15 Beta C,
16 Sunbeam, 19 Wolfram,
20 Brown, 21 Open-stack,
25 Rooster, 26 Round up,
28 Cuprous, 29 Premise

DOWN 1 Gemini, 2 Digi, 3
Tori, 4 Anomia, 5 Curassow,
6 Spaceballs, 7 Resistor,
8 Intercom, 14 Geek Nation,
16 Subtract, 17 Neomorph,
18 Moonrise, 22 Europa,
23 Aldrin, 24 Kepler, 27 Uvea

#186 Neural network Solution

There are several equivalent answers, all with half the weights zero and the other half $1/4$, $1/3$, $1/2$ and $2/3$.

To get $A = D = 1$ we must have $3s + 4t = 1$ and $3y + 4z = 1$. If we have both weights into one neuron as zero, that neuron will be zero. Since all the outputs are 1 or 2 and half the weights are zero, it must be that each neuron has one weight zero and one non-zero. Choosing s and z to be zero gives $t = 1/4$ and $y = 1/3$. In the same way, with $B = C = 2$ we have $3u + 4v = 2$ and $3w + 4x = 2$, which can be solved with u and x as zero, using $v = 1/2$ and $w = 2/3$.

Nose know-how

"Would male and female participants prefer nose-based gestures differently?" That question is seldom asked. But Jorge-Luis Pérez-Medina, Santiago Villarreal and Jean Vanderdonckt do ask it in their study "A gesture elicitation study of nose-based gestures," published in the journal *Sensors*.

The question, they say, helped guide their effort to pull together a taxonomy of nose-based gestures, which they hope will help them design new electronic sensing capabilities into eyeglasses, wristwatches and other devices.

Nose-based gestures needn't involve only the nose: any gesture that interacts with the nose can be considered nose-based. Fingers can be part of it, and so can other parts of the hand. Future research might involve other body parts and – maybe some day – foreign objects.

The researchers worked with 12 female volunteers and 12 male ones, asking them to make nose gestures to express specific commands, such as "turn on the TV", "turn off the TV", "turn the volume up" and "answer a phone call". They identified 912 distinct gestures, which they "clustered into 53 unique gestures resulting in 23 categories, to form a taxonomy and a consensus set of 38 final gestures".

Some gestures are easy to express in words, others aren't. Commonly gestured gestures include "tap", "push", "flick", "rub" and "pinch". Among the gnarlier are "snook" and "hold nostrils open". Gymnastics may be involved in certain of the more complex gestures: "double flick", "triple pinch" and "quadruple drag", for example. In contrast, one sees the gross simplicity of "finger in nose".

The study suggests that, mostly, no significant nose-gestural difference exists between men and women.

Further nose know-how

That nose-gesture study built on a small body of nasal-centric investigations done by others

Twisteddoodles for New Scientist



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that haven't yet drawn extensive follow-up work.

Vlastimil Havran wrote in to bring "NoseTapping" to Feedback's attention. In a study delivered at a conference in Luleå, Sweden, in 2013, Ondrej Polacek, Thomas Grill and Manfred Tscheligi opened some eyes with their paper: "NoseTapping: What else can you do with your nose?"

They begin on a touching note, with their focus on "nose-based interaction in which people tap or swipe with their nose on a touchscreen". NoseTapping, they say, could benefit people who use smartphones while wearing gloves in winter.

It is also relatively good for brief interactions, such as unlocking the phone or indicating "no" versus "yes". But there are hints about limits: "people are not willing to use such interaction

in case of more complex functionality like, for example, typing a message".

Limits also arise in a paper called "Hitting authentication on the nose: Using the nose for input to smartphone security", presented by Ann-Marie Horcher at a symposium in 2014. It identifies another drawback of NoseTapping: "there were concerns about cleanliness". Despite those concerns, Horcher proposes the use of nose prints, in which a nose pressed against a smart screen could be scanned, its image then becoming "a biometric point of authentication".

Horcher's early experiments, however, identify shortcomings: "The lower sensitivity of the nose and no visual feedback made positioning of the nose for success problematic."

No place like Neom

A new city planned for the Tabuk region of Saudi Arabia will be, say the planners, unlike other cities. One way it will be different is in its proportion. The city is designed to be only 200 metres wide, but 170 kilometres long.

Called "The Line", this new city is part of a larger project called Neom. Like most of Neom, The Line is mostly in the exciting planning-and-publicity stage of construction.

It may not have escaped your notice that The Line's proportion, 170,000 to 200 – let's call it the Neom ratio – differs from the ancient mathematical standard for beautiful proportion, the golden ratio.

The golden ratio's exact value is an irrational number defined by a three-step recipe: take the square root of 5, add 1 to it, then divide by 2. Actuaries, when they loosen their ties and lapse into inexactitude, say the exact value is slightly more than 1.6.

The exact value of the Neom ratio is 850. This is slimness far exceeding that of the kilopedal millipede (*Eumillipes persephone*). At 95.7 millimetres long and 0.95 millimetres wide, the Australian millipede was recently documented in the study "The first true millipede – 1306 legs long".

Nature is superabundant about patterns. Most simple patterns can be seen, if one pays attention, seemingly almost everywhere. The fruits of human manufacture are copious in the same way, with simple patterns recurring in various places. The Neom ratio can probably already be seen in the shape of many existing objects, and Feedback feels it would be intellectually exciting to identify and celebrate a few of these skinny standouts.

We invite you to help us amass a collection of the finest examples of the Neom ratio. What other physical objects have this same proportion, 170,000 to 200? Please tell us (being careful to supply clear examples, and to point to documentation thereof). ■



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Not sure what to see at New Scientist Live?

Here's what the *New Scientist* editorial team are most looking forward to...



Catherine de Lange
Magazine editor

I am anticipating high levels of FOMO this year as I try to choose between the different stages – there's just so much on offer. Having recently worked on a Q&A with Gillian Forrester about the way she's getting great apes to play with puzzles to try and understand the evolution of language, this one is a must-see for me. Like many, I'm sure, I'm also excited to hear Simon Baron-Cohen speak about his latest book, *The Pattern Seekers*, on the link between autism and invention. And I'm hoping that bringing my children along to the Engage Stage on Saturday to hear Jules Howard discuss the wonders of canine cognition might cure them of their chronic fear of dogs!



Chen Ly
Social media manager

This is my first New Scientist Live in London and I'm raring to go! There are so many brilliant talks on offer, but one on the top of my list is Gaia Vince's talk on why migration is the solution to climate devastation, poverty and much more. Climate change is an issue that weighs heavily on a lot of people's minds at the moment, including my own. It's profoundly important that people come together to share ideas on how to tackle climate change, and I can't wait to hear Gaia's thoughts.



Anna Demming
Features editor

I am on tenterhooks to host the Future Stage on Saturday this year – it truly is a line-up to have us thinking big and bold about a whole load of subjects. This'll include the biggest number in the world, what we can learn about the vast expanses of our oceans, and the plausible benefits of screen time for eliciting positive change. Covering such a diversity of ideas on just one stage is like walking into the pages of *New Scientist*! I hope to see you there.



Daniel Cossins
Head of features

The Universe Stage is very much my cup of tea. What could be more reviving than plunging headfirst into some of most fundamental questions there are? I'm particularly looking forward to Jeff Forshaw's talk, which will take us to the event horizon of a black hole and beyond. Jeff will be your guide for a whistlestop tour of what the black hole information paradox is revealing about the origins of space and time – and why it turns out the universe looks surprisingly similar to a quantum computer. Another one not to miss is Harry Cliff, who will be explaining how tantalising results from particle collisions at the Large Hadron Collider are suggesting that – whisper it – we might have found a new force of nature!



Rowan Hooper
Podcast editor

It would be horribly self-serving for me to suggest that the talk I'm most looking forward to is MY OWN TALK, but since no one else has mentioned it, I will! I'm going to be talking about my book, *How to Spend a Trillion Dollars*. I think it's really important because we can get paralysed by the size of the world's problems, but what I want to show is that the solutions, and the money – are out there. Also it's an interactive talk – I want to hear from you about how you would spend the money. It's not every day you get to pretend to spend a trillion dollars – so let's do it!

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